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by

Skindilias Christos

March 1986

Thesis Advisor: Tung X. Bui

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Distributed Decision Support System for Strategic Planning

by

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Lieutenant, Hellenic Navy
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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

This thesis focuses on the implementation and use of a multiple criteria, multiple-user Decision Support System capable of supporting distributed strategic decision making. An example of the use of such a distributed decision support system for selecting warships for the Hellenic Navy demonstrates the usefulness of the proposed group DSS.

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I. INTRODUCTION

A. DEFINITION OF THE PROBLEM

It is often observed that most of strategic problems are analyzed, discussed, and solved by many decision makers. The existence of multiple users have created a number of problems. First, it is difficult to physically reunite all decision makers in a geographic location. It is even more problematic in finding an appropriate time for all the group members. Second, the success of a group decision making process relies on the skillfulness of the group leader. Unfortunately, the quality of the group leader varies from one negotiator to the other, and from one situation to the other. In a military decision-making context, this problem becomes even more complicated if one considers the increasing complexity of the technological aspect of warfare and uncertainty regarding political issues.

This research proposes a computer-based group decision support system that attempts to resolve, or at least reduce, the problems enumerated above. It designs and implements a microcomputer-based DSS that allows group members to remotely and sequentially participate to collective decision problems. In particular, the proposed DSS is an expansion of a DSS based on multiobjective decision methods, is implemented in a local area network using a bus architecture and the Carrier Sense Multiple Access with Collision Detection (CMSA/CD) protocol. The CMSA/CD protocol is known by its relatively good performance, simplicity of implementation, and inherent system reliability. Such a protocol allows control of collective information exchange and data routing among group decision members.

The use of such a group DSS distributed in time and in space, is expected to eliminate the physical presence of group members and the need of scheduling meetings. More important, the proposed distributed DSS provides a objective and flexible framework to integrate organizational norms and constraint into the decision situation.

B. SCOPE OF THE RESEARCH

This research does not attempt to discuss the already large and interdisciplinary literature on group decision making. It attempts to expand some of the work in group decision support systems outlined by [Ref. 1 to 3] Two major expansions include the possibility for the user (i) to directly assess his preferences in cardinal terms, and (ii) to allow division of evaluation tasks according to individual expertise. In particular, this research primarily focuses on the software design and implementation of the networked micro-computer-based group DSS operating under a cooperative environment. However, the modular approach adopted for the proposed DSS would make it possible to expand the system to more complex form of group decision situations found, for example, in military strategic planning.

C. ORGANIZATION OF THE THESIS

Section II outlines basic definitions, concepts and architectures related to group decision making under computer-based settings. It emphasizes the communications aspects among group members via computerized media. Chapters III, IV, V and VI successively discusses the characteristics of the components of the group DSS. Two multiple criteria decision methods are presented in III.A. Four techniques of aggregation of preferences are defined in III.B. The multi-window interface has been adopted for the GDSS interface (section IV.A). Data definitions and dictionaries are described in section V. Section VI addresses special applications of the communications modules. Some observations on the development process of the GDSS are reviewed in section VII. Two examples of remote multiperson decision-making in military strategic planning are analyzed in section VIII. They illustrate the use of the GDSS to the selection problem of navy ships.

II. A FRAMEWORK FOR IMPLEMENTING REMOTE MULTIPERSON GROUP DECISION SUPPORT SYSTEMS

A. DEFINITIONS AND BASIC CONCEPTS

1. Definitions of group DSS

A collective decision-making process can be viewed as a decision situation in which (i) there are two or more persons, each of them characterized by his or her own perceptions, attitudes, motivations, and personalities, (ii) who recognize the existence of a common problem, and (iii) attempt to reach a collective decision [Ref. 1]. Furthermore, the group can interact simultaneously (i.e., pooled-interdependent mode) or make individual decisions separately and then confront and discuss the results (i.e.,sequential-interdependent).

One can observe three broad types of group decision making: a single decision maker acting in a collective decision environment, non-cooperative decision making, and cooperative decision making.

In the group decision-making situation with one person, a particular decision maker ultimately makes the decision and assumes responsibility for his line of action. However, the decision can be regarded as a collective one because of the existence of a dense network of influences that surrounds this single decision maker. In fact, other participants in the decision maker's organization can either support or act against the decision. Thus, the behavior and attitudes of other people who are indirectly involved in the decision-making process should be analyzed.

In the non-cooperative decision situation, the decision makers play the role of antagonists or disputants.

Conflict and competition are common forms of non-cooperative decision-making. While the former represents a situation in which disputants seek to hurt their opponents to pursue their own interests, the latter is characterized by the facts that each competitor is an action candidate, and is trying to outperform others.

In a cooperative environment, the decision makers attempt to reach a common decision in a friendly and trusting manner, and share the responsibility. Consensus, negotiation, voting schemes, and even the recourse to a third party to dissolve differences are examples of this type of group decision making.

Also, the literature in decision-making describes two types of decision situations involving more than one user: pooled interdependent and sequential interdependent. In a pooled decision-making situation, decision makers reunite together to form a more or less homogeneous group, and attempt to resolve a collective problem simultaneously. Elsewhere, in a sequential interdependent situation, members of the group can attack the collective problem at different periods in time, looking at different decision angles.

Another classification of group problem solving approach found in the literature is the distinction between content-oriented and process-oriented approaches. The first approach focuses on the content of the problem, attempting to find an optimal or satisfactory solution given certain social or group constraints, or objectives. By contrast, the second approach is based on the observation that the group goes through certain phases in the group decision-making process, and on the belief that there could be an arranged way to effectively deal with these phases.

When a collective decision fails, it becomes necessary for the participants in the group problem solving to start bargaining or negotiating until a consensus is found. While bargaining involves discussion within a specific criterion or issues, negotiation includes many criteria or issues in the discussion and search for consensus.

2. Assumptions

Without loss of generality, the cooperative multiple criteria group decision support system implemented in this thesis, is a DSS that (i) contains MCDM and supporting models in the individual Model component, and (ii) is able to support multiple decision makers via a Group DSS to reach a consensus in a cooperative environment.

Under certain decision circumstances, MCDM can play a crucial role in supporting group decision-making:

(1) Due to interpersonal differences, the existence of multiple and conflicting objectives is substantially more dominant in group decision-making than in single person decision-making;

(2) Subjective and qualitative assessments seem to play a more crucial role in group than in single user decision-making. It has been observed that it is relatively easy for decision makers to agree upon problems that have objective, quantifiable and well-defined attributes. Conversely, decision makers tend to disagree upon attributes that require subjective and qualitative assessments. Furthermore, in group decision-making, in addition to the evaluation of the situational problem, decision makers invariably attempt to evaluate and the decision analyses of themselves and others.

(3) The simplicity of MCDM outputs makes it easier to communicate, coordinate and aggregate individual analyses in the group decision-making process.

(4) The process often plays a more decisive role than the content in group problem solving. MCDM provide a simple but structured framework for controlling the decision-making process, i.e., assessment of alternatives, assessment of evaluation criteria, selection of an appropriate algorithm for assessment of preferences, and search for a solution or compromise;

(5) The division of decision processes into four stages also allows alternate utilization of both objective optimization and subjective evaluation.

(6) The iterative use of the MCDM processes would permit integration of predecision and postdecision phases in the habitual decision phase.

Specifically, the Co-oP DSS discussed in this research attempts to support the following decision situation:

(1) There are multiple users or decision makers. They may share an equal weight or have an unequal or 'hierarchically' distributed weight corresponding to a particular decision-making context.

(2) The group shares a common set of feasible decision alternatives. From this set of alternatives, the decision makers can either select one or more alternatives, or rank them according to a given set of criteria.

(3) Each decision maker may have personal objectives that reflect a priori values and as piration levels. Objectives are concretely expressed by criteria or attributes that are discrete, and at least ordinally measurable. Due to personal differences, individual decision outcomes--as opposed to acollective decision outcome that the group is trying to reach an agreement on--often differ from one decision maker to the other.

(4) The decision makers can be geographically dispersed and not required to log into the system at the same time. Via a distributed computer network system, they can communicate to others either sequentially or in an on-line mode.

(5) The decision makers interact in a cooperative manner and in a trusting environment. The system does not handle attempts to cheat or to seek coalition within sub-groups.

(6) The decision makers can either work closely together by forming a homogeneous group that uses a single decision support system, or work independently and then proceed to a multilateral assessment of the problem.

(7) The decision makers can segment a group decision problem into (hierarchically) sequential single user decision problems according to individual expertise and responsibility.

3. Communications Issues in Distributed Decision Making

In the context of a distributed group decision making, the demands for information exchange are marked by certain characteristics that should be considered in the design of communications capabilities. These characteristics could be best expressed by the requirements of having information exchanges that are (i) format-transparent, (ii) either constrained or unconstrained, and (iii) evolving throughout the decision phases.

a. Need for Format-Transparent Information Exchange

The demand for and/or generation of information among decision makers can take a variety of formats, ranging from unstructured and written notes to structured and numerical tables [Ref. 4]. The most complex form of traffic is the situation in which decision makers simultaneously require information exchanges on different subjects from different members using complicated combinations of input/output formats. It would then be necessary to identify, classify and convert information characterized by various individual formats into standard message formats, including the creation and maintenance of information related to group problem solving techniques, such as aggregation of preferences which requires some standardized inputs from individual results.

b. Limited versus Free Information Exchange

In some group decision situations, it is conceivable that all shared information is 'public' in that every member of the decision group has the right to access any information that is sent by one member of the group to another, whereas in some other decision situations, individual-to-individual or private message transfers are authorized [Ref. 5]. Thus, the creation, (statistical) maintenance and storage of message routing activities remains crucial in enforcing group norms concerning the type of information sharing (e.g., consensually predefined by the group prior to the group decision-making process, or monitored by the mediator.

c. Evolving Pattern of Communication Requirements

The requirements for information sharing evolves through various phases of the group decision-making process. For example, [Ref. 6] argues that a group problem solving phase that emphasizes search and innovation requires more spontaneity, and therefore an open communications pattern; whereas, bargaining activities that induce a preference for deliberate control of information exchange would be facilitated by using individual-to-individual communication channels.

Furthermore, empirical studies have shown that, under certain circumstances, communication channels can escalate conflict [Ref. 7]. While encouraging information exchange between group members is often recognized as an effective strategy to resolve individual differences, eliminating communication channels has shown its effectiveness in preventing deterioration of relationships. While the decision to encourage or discourage communication between decision makers depends on a number of unpredictable situation-dependent factors, the GDSS communications component should be designed in such a way that it can accommodate various communications needs and changes during the group decision-making process. In other words, the pattern of communications protocols should vary according to the dynamics of the group decision-making process.

4. The Role of the Communications Component

One of the roles of the communications component that emerges from the literature is that it makes it easier for each member of the group to electronically communicate without having to be concerned about detailed and complicated protocol procedures. This issue of user transparency is particularly crucial given the diversity, and consequently the complexity, of the communication requirements and facilities.

However, the effort to obtain ease of communication access is not unique to the design of group DSS. Rather, it has always been one of the most important objectives of computer networks design. Yet, one can identify at least three roles that are specific to a communications system in group problem solving. At different phases of the distributed decision process, the communications system can play the role of a coordinator, a detective, or an inventor.

a. The Coordinator Role

Most problem solving activity begins with situation analysis and problem definition. Situation analysis is characterized by a (common) recognition that there exists an urgent and important problem to be solved. Once identified in the situation analysis, a problem is transformed in the problem definition phase in such a way that solutions can be generated, analyzed and selected. [Ref. 8] and [Ref. 9] emphasize that the success of information gathering and problem definition relies on the ability of the group to eliminate mistrust and threat that could cause group participants to withhold or distort information. Walton [Ref. 6] suggests that by installing a communication medium that follows some norms of fairness (e.g., equality of participation, preserving autonomy), information exchange can be more abundant and accurate. The communication component should thus coordinate various protocols to engender participants' confidence. Such protocols could include the ones that (i) assure each member can successively broadcast his/her ideas given a equal amount of time, or (ii) support teleconferencing to synchronize arguments.

b. The Detective Role:

A decision maker's analysis could be distorted by (i) the individual's attempt to 'spy' on others activities, or (ii) the influence of some members who try to take over an individual's responsibility. The communications component should then play the role of detective to prevent unwanted data exchange or temporarily disable all links, or prevent malicious modification of public data. Concurrently, decision makers tend to delay sending their individual results. The communications component should press its users to submit opinions before a given due date.

From a general perspective, the detective role consists of enforcing communications protocols previously defined to drive the collective decision-making process.

c. The Inventor Role:

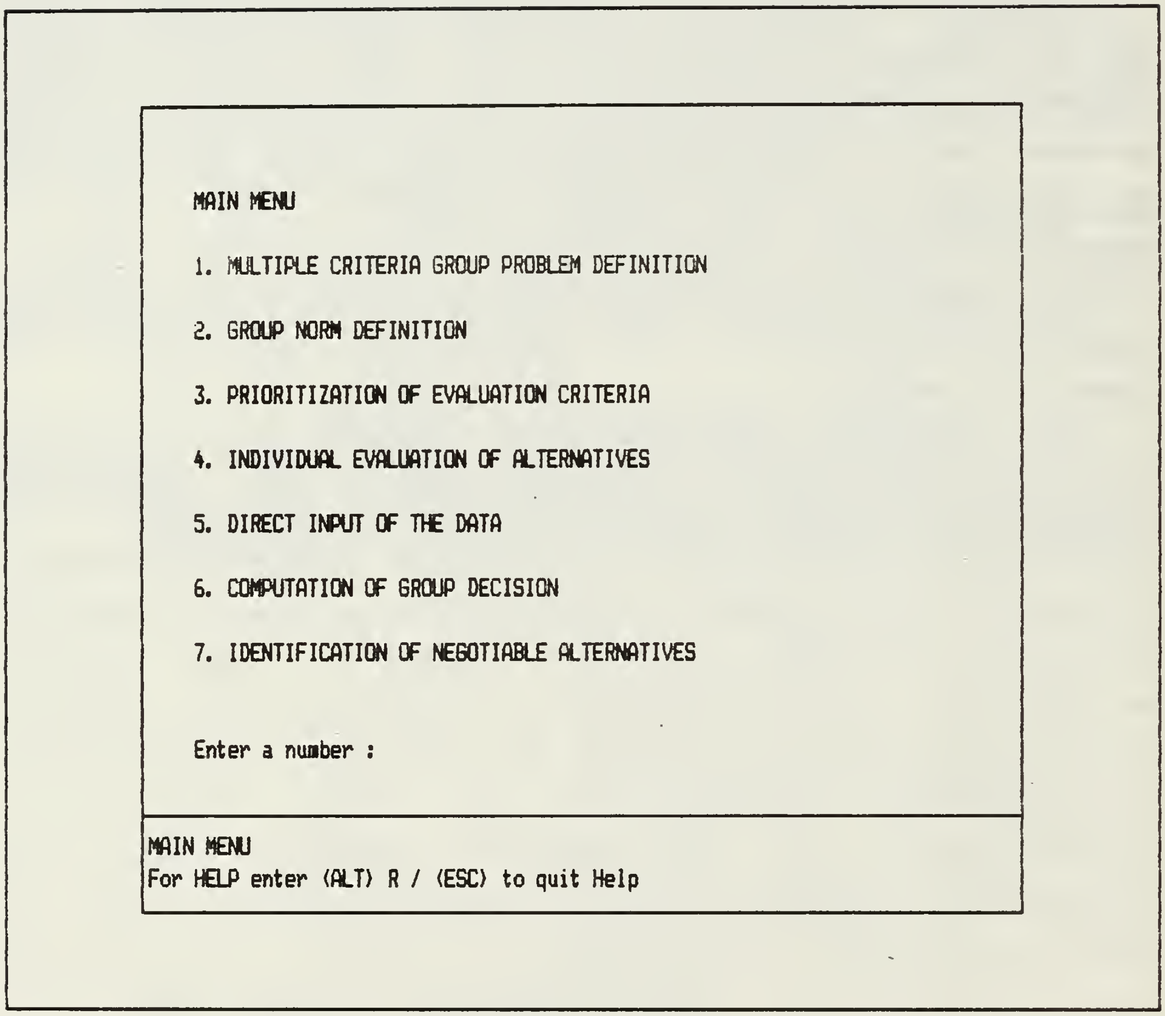
The inventor role is an extension of the coordinator role. Given the complex nature of a collective decision problem and the diverse and unpredictable decision approaches adopted by the participants, the communications component should be able to detect incompatible information exchange, and, if possible, propose alternate formats. The inventor role implies (i) potential for tolerance to uncertainty in requests and needs for data transfers, and (ii) continued search for communications operations that facilitate information exchange [Ref. 10]. Thus protocols for distributed GDSS should be able to analyze, evaluate and determine the content of transmissible information, rather than simply perform a transport task.

The functions of the communications component are at least twofold. First, it monitors a broad spectrum of data transports during a group problem solving process. This transport function ranges from information exchange to information hiding, from selective and personalized routing to collective diffusion of data from public to private information. Second, it coordinates various communications activities (i.e., initialization, operation during consensus search, negotiation and mediation) by making it transparent to the members of the decision group.

B. AN ARCHITECTURE FOR GROUP DSS

Co-oP is a network of microcomputer-based process-driven DSS for cooperative multiple criteria group decision making (Figure 1). Each participant of the group decision making process has his own individual DSS whose model base is based on multiple criteria decision methods (MCDM) and other personal decision support tools. The group DSS contains a set of aggregation of preferences techniques and consensus seeking algorithms that can be used in conjunction with individual MCDM.

The individual DSS are linked together by a microcomputer local area network. The latter support both locally and remotely (via modem) linked individual workstations.



MAIN MENU

1. MULTIPLE CRITERIA GROUP PROBLEM DEFINITION
2. GROUP NORM DEFINITION
3. PRIORITIZATION OF EVALUATION CRITERIA
4. INDIVIDUAL EVALUATION OF ALTERNATIVES
5. DIRECT INPUT OF THE DATA
6. COMPUTATION OF GROUP DECISION
7. IDENTIFICATION OF NEGOTIABLE ALTERNATIVES

Enter a number :

MAIN MENU
For HELP enter (ALT) R / (ESC) to quit Help

Figure 1. The Main Menu

III. THE MODEL COMPONENT

The Model Component of a DSS is expected to support the user perform the following problem-solving activities: projection, deduction, analysis, creation of alternatives, comparison of alternatives, optimization and simulation [Ref. 11]. The literature in DSS often identifies three modules in a DSS model component: the model base, the model base management, and the interface unit. This chapter describes the three components of the group DSS.

A. THE MODEL BASE

The Model Base of a DSS consists of a library of decision models that help the group members perform individual and group analyses.

1. The Model Base for Individual Decision Making

In addition of the possibility for the user to directly enter his preferences/assessments to the system and if needed, share them to other group members, the purpose of the Co-oP MCDM model base is to provide the decision makers with a set of decision models that can solve the most common types of decision problems. Co-oP contains two models that (i) cover three basic decision situations, i.e., selection, ranking, sorting, (ii) are not excessively difficult to use for the decision makers, and (iii) could interact with techniques of aggregation of preferences. The MCDM methods implemented in each of the individual DSS are the Analytic Hierarchy Process (AHP) [Ref. 12], and ELECTRE [Ref.13]

ELECTRE and AHP have been selected for two reasons:

(1) The two MCDM are conceptually robust, and practically easy to learn and use. They have proven their usefulness in aiding a number of ill-defined

decision situations (for example, [Ref. 14] and [Ref. 15])

(2) Neither ELECTRE nor AHP require full information on the decision maker's preferences and assessment of alternatives, and hence, give more autonomy and control to the decision maker [Ref. 16]. This feature makes it easier to expand the algorithm to resolve group decision making.

This section briefly outlines basic concepts of the ELECTRE and AHP methods.

a. The ELECTRE Method: Basic Concepts

There are a number of reasons that make it difficult for a decision maker to exhaustively compare all known alternatives. First, the decision maker often cannot compare some alternatives, due to uncertainty associated with the measurements and evaluation. Second, the decision maker may be unwilling to compare two alternatives because they are incomparable; e.g., option A is better than option B by some criteria, whereas B is better than A by some other criteria. The notion of indifference in utility theory does not reflect this incomparability [Ref. 17]. Last but not least, the ill-structuredness and occasional inconsistency of the decision maker's preferences are serious obstacles to enforcing the complete comparability of alternatives (see [Ref. 12]).

The concept of outranking relations seeks to compare decision alternatives only when the decision maker's preferences are well defined. In other words, a_i outranks a_k when the information obtained from the decision maker's preferences safely justifies the proposition that a^i is at least as good as a^j.

The outranking relation can be explained by two further concepts: the presence of concordance (i.e., for a sufficiently important subset of evaluation criteria, A is at least weakly preferred to B); and the absence of discordance (i.e., among the criteria for which B is preferred to A, there is no significant discordant preference that would strongly oppose any form of preference of A over B).

These indexes are used in conjunction with concordance and discordance 'thresholds' chosen arbitrarily by the decision maker in the interval [0, 1]. The concordance threshold, p, is more severe as it approaches 1; the discordance threshold, q, is more severe as it approaches 0. Then, the outranking relations can be summarized as follows:

IF	THEN
$C_A/B \geq p$ and $D_A/B \leq q$	A outranks B
A outranks B, and B outranks A	The alternatives are equivalent
Otherwise	The alternatives are incomparable

The decision maker can start with a less severe set of threshold values, and then sharpen them to reduce the number of outranking relations.

b. The Analytic Hierarchy Process: Basic Concepts

The Analytic Hierarchy Process (AHP) is a MCDM method that attempts to support complex decision problems by successively decomposing and synthesizing various elements of a decision situation [Ref. 12]. Like ELECTRE, AHP permits subjective and qualitative pairwise comparison of alternatives. Unlike ELECTRE whose concept is based on the notion of non-dominated alternatives, AHP has its foundation on the concept of priority. The latter can be defined as a 'level of strengths' of one alternative relative to another. Departing from a predefined priority scale, the decision maker is asked to build a positive reciprocal matrix of pairwise comparison. A vector of priority can be derived by computing the eigenvector of the reciprocal matrix. The property of the eigenvector resides in the fact that it is a consistency indicator. Consistency is obtained when pairwise comparisons are transitively and proportionally consistent.

Additional algorithms are added to help measure the decision maker's consistency. These algorithms contrast the user's evaluation scores with (i) a randomly simulated score that represents the most irrational evaluation, and (ii) the eigenvalue that represents the most accurate consistency. The examination of the consistency values enables the user to eventually revise initial judgments, and, if appropriate, modify them to improve overall consistency.

2. The Model Base for Group Decision Making

Four techniques of aggregation of preferences are implemented in the GDSS. They are chosen because of their popularity. These include the additive function, the multiplicative function, the sums-of-the-ranks approach, and the sums-of-the-outranking- relations approach.

In conjunction with the techniques of aggregation of preferences, the weighed majority rule is also implemented to account for the distribution of decision power among decision makers. This rule allows the group members to differentiate their decisional power according to various degrees of expertise or organizational hierarchies.

(1) The Sums-of-the-Outranking-Relations Principle

This technique is derived from the sum-of-the-ranks technique found in the literature of aggregation of preferences. Formally, it can be expressed as follows:

$$\text{Max } [\ i=1 \ \ (k=1 \ \ o_{i,k}\ )\ ]$$

This technique should be used only with extreme care. Experience with this technique has shown that the idea of selecting the alternative that has the highest number of outranking relations works fine only when the number of alternatives are small. An example with three decision makers and three alternatives, with a_3 as the elected alternative, is given below.

Ordinal Ranking				Outranking Relations				
Rank	DM_1	DM_2	DM_3		a_1	a_2	a_3	Sums of the Relations
1	a_1	a_3	a_3	a_1	–	2	1	3
2	a_2	a_1	a_2	a_2	1	–	1	2
3	a_3	a_2	a_1	a_3	2	2	–	4 <-Max

(2) Sums-of-the-Ranks Rule

The sums-of-the-Ranks rule (Borda, 1781) can be defined as follows:

where r_{di} is the rank assigned by decision maker d to alternative a_i. The example below illustrates this rule.

Altern.	DM_1	DM_2	DM_3	Sums-of-the-Ranks
a_1	4	4	2	10
a_2	1	1	3	5 <-- Min
a_3	2	2	4	8
a_4	3	3	1	7

Due to its computational simplicity this technique is widely used to determine consensus ranking. Note that the averages-of-the-ranks rule yields the same results. However, when there are ties, the results are different.

(3) Additive Ranking

In the additive ranking method, group results are obtained by computing the arithmetic mean of the individual rankings assigned to each alternative.

Due to its simplicity, this method remains one of the most popular aggregation of preferences techniques. The example below illustrates this rule.

Altern.	DM_1	DM_2	DM_3	Additive Ranking
a_1	4	4	2	3.33
a_2	1	1	3	1.66
a_3	2	2	4	2.66 --> MAX
a_4	3	3	1	2.33

(4) Multiplicative Ranking

The philosophy that underlies the multiplicative approach is to allow more voting power to each decision maker of the group. In effect, the multiplication of individual cardinal rankings amplifies the individual opinions. Specifically, it allows vetoes to take place. he example below illustrates this rule.

Altern.	DM_1	DM_2	DM_3	Multiplicative Ranking
a_1	4	4	2	3.17480
a_2	1	1	3	1.44224
a_3	2	2	4	2.51984
a_4	3	3	1	2.08008

B. THE MODEL MANAGER

The role of the model manager is to coordinate various modelling activities of the GDSS. In Co-oP, the multiple criteria group decision making is decomposed into five decision processes (see Figure 2).

(1) Definition of the Group Problem

The group must agree upon a common problem and delegate a group member -- usually the group leader or the secretary -- to define a problem. In the Co-oP context, the defined group problem consists of identifying the alternatives and evaluation criteria. Section VIII provides an example of this process.

(2) Group Norm Definition

The group has to identify its members and assign individual passwords. It also has to agree upon the way it handles data transfers, interactive conversation, utilization of electronic mail, and the type(s) of techniques of aggregation of preferences adopted. Division of evaluation tasks between group members can also be specified. The group can also request automatic selection and computation of appropriate decision technique.

(3) Individual Evaluation of Criteria

This process requires that each group member prioritize his/her evaluation criteria. This can be either accomplished by asking each decision maker to directly assign weights to the criteria or use the Analytic Hierarchy Process scheme to generate the weighed or priority vector. Co-oP allows elimination of weak criteria.

(4) Individual Assessment of Alternatives

Given a chosen problem, this process allows the group members to individually express their preferences regarding the alternatives. This process can be either direct (i.e., the user enters cardinal weights to each alternative) or indirect (i.e., the group member uses one or two available MCDM techniques).

(5) Computation of Group Results

Guided by the instructions defined in the group norm (i.e., the second process), group results are automatically computed once all individual analyses are submitted.

1. Integration of Models

Unless otherwise specified by the group norm, the Co-oP group module automatically searches for all aggregation techniques that are compatible with the individual MCDM used. If direct assessment of alternatives or AHP has been adopted by every group member for individual assessment of alternatives, all of the four implemented techniques will be computed, since the latter are compatible with the AHP in that they are based on cardinal preferences. However, the ELECTRE method can work only with the sums-of-the outranking-relations and, to a certain degree, the sums-of-the-ranks algorithms.

When both available MCDM are used concurrently by a group member, the Co-oP model manager automatically searches for group decision techniques that can accept inputs from both AHP and ELECTRE. When a single user alternately uses both available MCDM, the Co-oP model manager sequentially displays group results according to all possible combinations of individual methods.

Such a sensitivity analysis constitutes a point of departure for the group to start exchanging points of view and directions to reach agreement, and, if any, reducing tension. The group can then temporarily exit from ELECTRE, and use the electronic notepad to informally resolve these problems of control and of tension management. If some concessions can be obtained, the participants can return to ELECTRE and modify evaluation scores accordingly. By switching back and forth between the individual DSS and the group DSS , the participants can perform 'sequential concessions'.

2. Combined Use of MCDM and Techniques of Aggregation of Preferences

Bui [Ref. 2] argues for a unified MCDM framework. Such an attempt is necessary to (i) support a wide range of decision situations, (ii) enable economy of information search, (iii) allow division of evaluation tasks. In the Co-oP version implemented for this thesis, there are three possible levels of interaction between ELECTRE and AHP. First, ELECTRE, when used alone, assumes that the decision has a defined vector of criterion weights. AHP can help the ELECTRE user perform prioritization of evaluation criteria prior to the pairwise evaluation of alternatives. Second, when the size of a decision problem is large, the number of inputs required to perform the AHP method can be excessive. The Co-oP user can use ELECTRE as a sorting tool to reduce the problem size, and then utilize AHP. Third, since the two methods refer to the same decision space (defined in the

Co-oP first process), they can be concurrently used to verify the decision maker's consistency.

C. THE LINKAGE MODULE

The purpose of the Co-oP Linkage Module is to feed input data to various models of the Model Base and to route output data to various files managed by the Data Base Component.

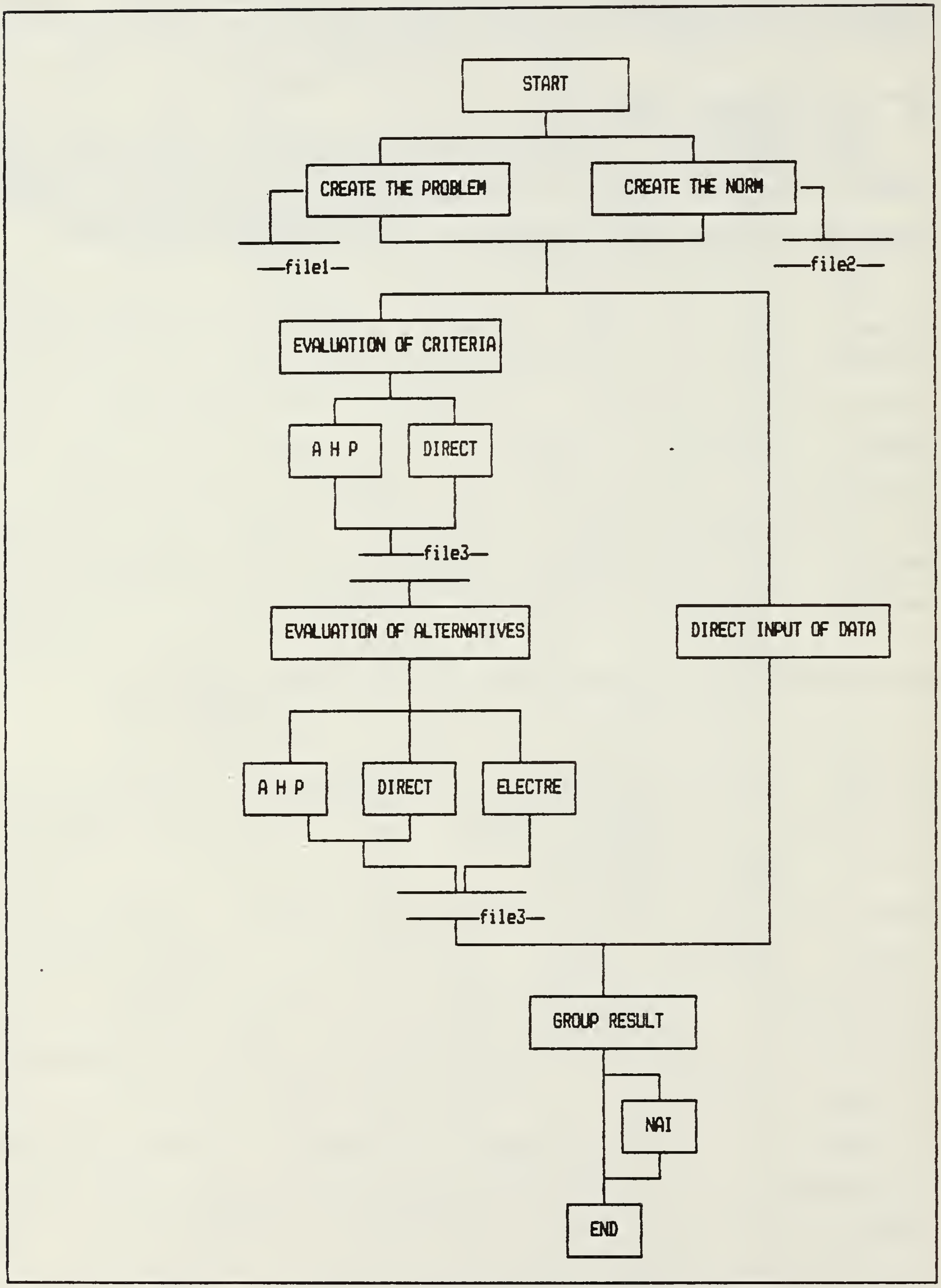


Figure 2. The Co_oP Decision Making Process

IV. THE INTERFACE COMPONENT

A. SCREEN DESIGN

Despite the structured aspect of the multiple criteria group problem solving processes, it remains an eventual burden for the decision makers to memorize what he has done in the previous steps. Maintaining a high degree of coordination and cohesiveness of thoughts is particularly prevalent in complex decision problems [Ref. 17].

Screen Format: During the problem definition and the group norm definition processes, data entry in outline form is adopted. Such an entry form would not only facilitate the thinking process of themanagers, but also help decompose objectives into hierarchical levels [Ref. 12]. Section VIII exhibits examplesof the outline forms used for defining the collectivedecision problem and the definition of group norms.

For the multiple criteria group decision processes (i.e., processes 3 through 7), Co-oP proposes a screen format that displays simultaneously four different windows (see Section VIII). Whenever possible, Co-oP uses the same screen format throughout its usage. The purpose of such a design is to provide the user with a synoptic andfamiliar snapshot of the current state of the problem, throughout the entire decision-making process.

The Step Window located at the bottom screen keeps the decision maker up to date on the current decision making status. It consists of a two-linestatus text indicating alternatively the current step in the hierarchy of group problem processes, and any required prompts or diagnostic messages related to the DSS-user interaction.

The Dialogue Window provides a conversational medium between the decision maker and the DSS. It enables the Question/ Answer mode of interaction to be accompanied by verbal and color/graphic explanation of various processing sequences and intermediate results.

To support the decision maker's orientation during the group decision-making process, the Working window at the upper left corner of the screen reminds the user of vital information from past dialogue or inputs. Also, it displays the results obtained by other participants if requested.

The Solution window is located at the upper right of the screen. It displays intermediate and finalresults including statistical indexes, and highlights optimal values. Tabular outputs and bar graphs are combined to provide alternate ways to represent outputs.

Throughout the entire Co-oP process, the windows can be recognized by their colors. However, they vary in size according to the required amount of information displayed (e.g., number of decision makers, number of decision alternatives, and number of evaluation criteria).

In addition to the above mentioned window, an electronic notepad window can be invoked at any time to make use of person-oriented and unstructured communications.

B. DIALOGUE STYLE

In addition to the window structure that governs the entire Co-oP group decision making process, Co-oP combines menus and questions to communicate with its users. The purpose of these dialogue styles is to provide the users with a structured, simple and controlled framework to interact with an integrated set of multiple criteria group decision methods. Whenever possible, concise queries and uniform terminology are used throughout the six processes of the Co-oP group decision making process.

The use of menus and queries also facilitates establishing error procedures. Although error control procedures are not unique to the design of multiple user interface, an eventual I/O error occurring in a group DSS can generate unexpected and severe consequences in a distributed DSS. Input control routines have been implemented at each entry level to minimize the likelihood of input errors, or to maximize the possibility of recovering from errors when the latter occur.

To handle errors made by the users, Co-oP provides two types of error control procedures. The first type of procedure detects syntax errors. For instance, entering a negative number of decision makers or typing an invalid filename would be gracefully rejected by the Co-oP dialogue manager. The second type of control routines attempts to prevent decision makers from violating basic assumptions or rules of the decision methods. For instance, the dialogue manager will refuse a concordance threshold higher than 100 percent when ELECTRE is used.

Co-oP also generates short explanation messages in the Step window to maintain the user confidence in the system, or at least make the multiple criteria group decision making less unnatural to the users.

C. THE HELP COMMANDS

Help facilities are implemented on a separate and resident program that can be concurrently invoked during the Co=oP decision-making process. Due to its relatively large amount of text, the help program is hierarchically broken down into eight section (see Figure 3).

```
HELP   FOR   Co_oP

             MAIN MENU

             (1)  General  Information

             (2)  Create  a  new  Problem

             (3)  Prioritization  of  Evaluation
                  Criteria

             (5)  Evaluation  of  Alternatives

             (6)  Direct  Input  of  Weights

             (7)  Computation  of  group  Decision

             (8)  N  A  I

             SELECTION  :  _
```

```
HELP   FOR   Co_oP

             SUBMENU  1  -  GENERAL  INFORMATION

             (1)  What  Co_oP  IS

             (2)  How  to  Use  It

             (3)  AHP  Method

             (5)  Electre  Method

             SELECTION  :  _
```

Figure 3. The Help Menu

V. THE DATA COMPONENT

A. THE DATA STRUCTURE

The current version of Co-oP is a process-centered group DSS, as opposed to a data-centered DSS (for instance, see [Ref. 18]). As a consequence, the structure of the Co-oP data component is minimal. Its objective is to (i) insure smooth and fast data transport from one MCDM step to the other, and (ii) facilitate data exchange between decision makers.

Data files are grouped according to each process. These include (i) a file containing the problem definition (Process 1), (ii) a norm file for each group norm, (iii) a solution file for each group members, and (iv) a group results file for each decision problem. Data dictionaries are given in Tables 1, 2, 3 and 4.

To minimize the time needed for data transfers between individual workstations, data files are physically centralized and stored in the server of the Local Area Network. However, they are functionally distributed in that they can be accessed only by authorized group members.

B. THE DATA MANAGER

In the current version of the GDSS, the Data Manager performs a double functions. It (i) assures that data are correctly transferred to their location, and (ii) checks the consistency transfer, i.e., validating the number of data modification.

TABLE 1
LOGICAL DATA BASE RECORDS FOR STORE THE DATA OF A PROBLEM

PROBLEM = RECORD

name1	string, it holds the name of the problem.
levels	Integer,it holds the number of the criteria 1 - 5
numofalternatives	Integer, it holds the number of the alternatives that a problem have
level1	array[1..5] of string, it holds the names of the criteria of level 1 - 5
level2	array[1..5,1..5] of strings, it holds the names of the criteria of sublevel 1.(1-5) - 5.(1-5)
level3	array[1..5,1..5] of strings, it holds the names of the criteria of sublevel 1.1.(1-5) - 1.5(1-5)
level4	array[1..5,1..5] of strings, it holds the names of the criteria of sublevel 2.1.(1-5) - 2.5(1-5)
level5	array[1..5,1..5] of strings, it holds the names of the criteria of sublevel 3.1.(1-5) - 3.5(1-5)
level6	array[1..5,1..5] of strings, it holds the names of the criteria of sublevel 4.1.(1-5) - 4.5(1-5)
level7	array[1..5,1..5] of strings, it holds the names of the criteria of sublevel 5.1.(1-5) - 5.5(1-5)
level1	integer, it holds the number of the criteria 1 -5
sublevel1	array[1.5] of integers, it holds the number of the criteria for sublevels 1.(1-5) - 5.(1-5)
sublevel2	array[1..5,1..5] of integers, it holds the number of the criteria in sublevels 1.1.(1-5) - 5.5.(1-5)
alternatives	array[1..15] of strings. It holds the names of the alternatives of the problem

END

TABLE 2

LOGICAL DATA BASE RECORDS FOR STORE THE DATA OF A PROBLEM

SOLUTION1 = RECORD

pfactor,qfactor	integers, they holds the Concordance and Discordance Threshold
numofcriteria	integer, it holds the number of criteria
numofalternatives	integer, it holds the number of the alternatives
alternatives	array[1..9] of string , it holds the name of the alternatives
numofusers	integer, it indicates the number of the users
solved	array [1..3] of boolean,it indicates if a particular user has solve the problem
grading	array[1..3] of array[1..3],it contains weights of criteria 1 - 5 for each user
completed	boolean, it indicates if the evaluation o the criteria is completed of all the user
completedall	boolean, it indicates if the problem is solved
vector1	array[1..5] of reals, it contains the weights of the criteria of sublevel 1 -5
vector2,vector3, vector4,vector5, vector6,vector7	array [1..5,1.5] of reals, it holds the weights of all the rest criteria
normvector1	array [1..125] of strings, it holds the names of the final criteria (after the evaluation)
normvector2	array [1..125] of reals, it holds the weights of the final criteria (after the evaluation)
normindex	array[1..vectorg ;
altmatrix	altrix[1..# alternatives,1..# criteria]
finalindex	array[1..3] of boolean, it indicates if a specific user has compute the evaluation of the alternatives

TABLE 2
(continued)

```
ahp : record
  status          boolean, it indicates if the solution
                  of a problem has been computed with the
                  AHP
altvector1        array[1..9] of real, it contains the final
                  weights of the alternatives
numoftries        integer,it indicates how many times the
                  user has modify the solution of the
                  problem
end;
electre : record
  status          boolean, it indicates if the solution of a
                  problem has been computed with the ELECTRE
outranking        array[1..9,1..9] of char, it contains the
                  outranking matrix for the alternatives
numoftries        integer,it indicates how many times the
                  user has modify the solution of the
                  problem
end ;

END ;
```

TABLE 3
LOGICAL DATA BASE RECORDS FOR STORE THE DATA OF A PROBLEM

usersnames	array [1..3] of stings, it holds the names of the users
usersids	array [1..3] of strings, it holds the users id
numofcriteria	integer, it holds the number of criteria
numofalternatives	integer, it holds the number of the alternatives
alternatives	array[1..9] of stringd, it holds the name of the alternatives
normvector1	array [1..125] of strings, it holds the names of the final criteria (after the evaluation)
normvector2	array [1..125] of reals, it holds the weights of the final criteria (after the evaluation)
ahp : record	
status	boolean, it indicates if the solution of a problem has been computed with the AHP
altvector1	array[1..9] of real, it contains the final weights of the alternatives
numoftries	integer, it indicates how many times the user has modify the solution of the problem
end;	
electre : record	
status	boolean, it indicates if the solution of a problem has been computed with the ELECTRE
outranking	array[1..9,1..9] of char, it contains the outranking matrix for the alternatives
numoftries	integer, it indicates how many times the user has modify the solution of the problem
end ;	
END ;	

TABLE 4
LOGICAL DATA BASE RECORDS FOR STORE THE DATA OF A PROBLEM

NORM = RECORD

numofusers	integer, it holds the number of the users that are going to solve the problem
modifytimes	integer, it indicates how many times a user can modify the solution of the problem
lasttime	integer, it indicates the last date that a user must submit his solution
usersnames	array [1..3] of stings, it holds the names of the users
specindex	array[1..5] of strings, it indicates the criteria that each user is going to solve in the division of tasks case
usersids	array [1..3] of strings, it holds the users id
weight	array[1..3] of real, it indicates the weight of the decision of each user
agregation	boolean, it indicates if we are going to use all the techniques of aggregation of preference
nai	boolean, it indicates if the program will use NAI automatically after the complication of the group result
specialized	boolean, it indicates if we are going to use division of tasks or not
broadcasting	boolean, it indicates if the users have the right to see the others users results
modify	boolean, it indicates if the user has the right to modify the solution of the problem
agregationname	array[1..4] of characters, it indicates the techniques of agregation of preference that we are going to use

END

VI. THE COMMUNICATIONS COMPONENT

A. THE GROUP NORM CONSTRUCTOR

The Co-oP Group Norm Constructor resides in the second Co-oP multiple criteria decision making process. The group leader or secretary has to initiate the group decision making by (1) identifying the group members, (2) assigning respective decision weights, (3) determining the mode of group decision making (e.g., division of evaluation tasks or 'pooled' decision making), (4) selecting the techniques of aggregation of preferences, (5) setting the mode of information exchange (i.e., broadcast of individual results), and (6) defining the deadline for the group members to submit individual results.

B. THE GROUP NORM FILTER

The Co-oP Group Norm Filter consits of a set of subroutines that enforce the norms set by the Group Norm Monitor.

C. THE FORMATTER

The main role of the Co-oP formatter is to convert individual results computed by the ELECTRE and AHP methods to data formats that can be inputted into the modules containing the techniques of aggregation of preferences. For instance, individual cardinal rankings are converted into ordinal rankings for the sums-of-the-ranks algorithm.

VII. IMPLEMENTATION OF THE GDSS

A. SOFTWARE STRUCTURE

Turbo Pascal cannot handle program files whose size is larger than 62 kilobytes. To override such constraint, Co-oP has been decomposed into 15 including files. The latter are described below. Also, filenames under IBM-PC-DOS cannot have more than eight letters, abbreviated filenames have been used.

DIRLIST1

PROCEDURE DIRLIST displays on the scrren the existing files of previously defined problems (problem_name.def)

DIRLIST2

PROCEDURE DirListA The same as above but for the norms files (norm_name.gn).

PROCED

FUNCTION STUPCASE turns a string to uppercase characters.

FUNCTION EXIST examines if the file requested by a user to access exists. If it exists it returns the value TRUE else returns the value FALSE.

PROCEDURE WAIT stops the execution of the program until the moment that the user will hit a key.

PROCEDURE CLEARSCREEN clears the screen for line 1 to line 10 to make space for new data.

PROCEDURE CONVERT converts a string to the corresponding numerical value

PROCEDURE IDENTIFY reads the user input and accepts it only if it is Y or N.

PROCEDURE CHECKNUMBER reads a number that the user enters and accepts it only if it is within a predefined range.

PROCEDURE SORT1 sort an array of numbers.

PROCEDURE WRITENORMFILE reads from the program the current norm data and writes them in a file (e.g., data of the current norm).

PROCEDURE WRITEPROBLEMFILE reads the norm data from the current norm file and passes them to the program.

PROCEDURE READPROBLEMFILE reads from the program the problem data and writes them in a file (e.g., data of the current problem).

PROCEDURE READNORMFILE reads the data for the corresponding norm file and passes them to the program.

PROCEDURE READSOLUTIONFILE read the data from the user file and passes them to the program

PROCEDURE WRITESOLUTIONFILE reads the current user data from the problem and writes them to the current user file.

FILES

PROCEDURE OPENFILE opens for the first time a file that it will keep the data of a new problem.

PROCEDURE OPENSOLUTIONFILE opens for the first time a file that it will keep the data of the solution of the problem (one for each user).

PROCEDURE OPENNORMFILE opens for the first time a file that it will keep the data of a new norm.

UTILITES

PROCEDURE DISKDATA asks the user if he wants to see a predefined problem or norm.

PROCEDURE DISKSTATUS displays all the existing problems and norms of the current directory.

PROCEDURE READ1 asks the user the name of the problem that he wishes to solve.

PROCEDURE READ2 asks the user the name of the norm that he wants to use.

PROCEDURE READ3 asks the user's name.

PROCEDURE READ4 asks the user's password.

PROCEDURE READ5 asks the decision method that the user is going to use.

PROCEDURE DATA includes read1, read2, read3, read4.

PROCEDURE PRIORITYOFCRITERIA permits evaluation of evaluation criteria.

STEP1

PROCEDURE CREATEPROBLEM reads the data of a new problem and writes them in a file.

PROCEDURE DISPLAY displays the data of a problem to the screen after the request of the user.

PROCEDURE CORRECTDATA corrects the data of the problem in case of an error occurs.

STEP2

OVERLAY PROCEDURE NORMDEFINITION reads the data of a new norm and writes them in a file.

STEP2-1

PROCEDURE NORMSELECTION asks the user to select one of the existing norms.

PROCEDURE DISPLAYNORM displays the data of a norm to the screen.

STEP3

PRIORITYOFCRITERIA is the main program for the evaluation of the criteria.

STEP 3-1

OVERLAY PROCEDURE EVALUATE includes the evaluation of a set of criteria using AHP.

OVERLAY PROCEDURE DIRECT1 is similar to the previous procedure but using direct mode.

STEP3-2

PROCEDURE SELECTCRITERIA computes the final weights after the computation of all the sets of criteria.

PROCEDURE FINALCRITERIA gives the user the opportunity to reduce the number of the final criteria.

STEP4

PROCEDURE SOLVEWITHAHP controls the evaluation to the alternatives if the user select : AHP, direct mode, general direct mode, and displays the final weights for the alternatives.

PROCEDURE COMPUTEALTERNATIVES controls the computation of the alternatives according to the method that the user is going to use.

STEP4-1

OVERLAY PROCEDURE EVALUATE1 evaluates a set of alternatives using AHP.

OVERLAY PROCEDURE EVALUATE3, upon request, assigns weights in a set of alternatives directly (without grading previously the criteria).

OVERLAY PROCEDURE DIRECT2A evaluates a set of alternatives using the direct mode.

STEP4-2

OVERLAY PROCEDURE ELECTRE evaluates a set of alternatives using the ELECTRE method.

STEP6

OVERLAY PROCEDURE GDSS computes the group results.

B. EFFORT DISTRIBUTION AND MAINTENANCE PROBLEMS

1. Effort Distribution

The development of the software took approximately six man-months. The effort distribution is indicated below:

TABLE 5 EFFORT DISTRIBUTION

	AHP & ELECTRE	GROUP MODULE	USE OF NORM	DIVISION OF TASKS
Requirement Analysis	3	6	8	2
Initial Design	5	3	3	5
Detailed Design	–	–	–	–
Coding	17	11	5	3
Unit testing/Debugging	6	5	2	3
Testing Integration	4	5	2	2
% Of the Total time	35	30	20	15

It is worth noticing that the iterative design adopted for the development of Co-oP has helped in incrementing the functionalities of the software.

2. Implementation Problems and Maintenance Issues

(1) Design of Algorithms:

The understanding of algorithms, conversion of algorithm in structured pseudo-codes required elaborated design.

(2) Programming Language:

Mastering the language adopted for the software development has taken a substantiallearning effort. Window scrolling, overlays, cursor handling--due to the limited capabilited of the programming language --took a non-negligible learning effort.

(3) Debugging logical errors:

Due to the complexity ofthe data structures, in particular, the manipulationof matrices in the AHP techniques and the integration of multiple-user files, testing the correctness of data transfers represented an important part in the testing phase.

VIII. REMOTE MULTIPERSON DECISION MAKING IN MILITARY, STRATEGIC PLANNING

A. EXAMPLES OF POSSIBLE USE OF GDSS IN THE MILITARY CONTEXT

The proposed software is most appropriate for decision situations where there is distribution in space and in time. Such decision settings are often encountered at various high-level decision making in the armed forces as well as in the civil government. The example discussed below illustrates an decision example that deals with the selection of a naval warship.

B. A HYPOTHETICAL EXAMPLE

To exemplify the potential usefulness of the developed software, this section describes a hypothetical example. The latter consists of selecting a naval ship. Two scenarios are discussed below. The first one assumes a multiple-user decision situation where there is an exclusive division of tasks at upper-level decision. In other words, each group member is assumed to have special expertise and is assigned to evaluate the alternatives according to the decision criteria closely related to his knowledge. The second scenario illustrates a group decision situation where collective assessment at the staff level is performed. In other words, each group member has his/her opinions on the entire set of evaluation criteria.

SCENARIO 1: DIVISION OF TASKS AT UPPER-LEVEL DECISION

(1) Decision alternatives:

Naval ships can be bought from three countries: the United Kingdom, the Netherlands and West Germany. This example concentrates on a particular class of warship, i.e., the Corvette. For the purposes of this scenario, the specifications of the three ships are given in Tables 6 and 7.

(2) Decision makers:

Decision makers include the chief of the weapon department, the chief of the engineering department and the chief of the electronics department. All of the above officers are under the command of the chief of department of new constructors, a Real Admiral. Each of the officers has specific expertise in the performance evaluation of the ship candidates. The chief of the weapon department, officer enjoys however the highest decision power. It is assumed that the decision makers operate under more or less complete information about the ships. Each decision maker has a technical staff of his own that performs detailed surveys of the characteristics of the ships.

(3) Decision making norms:

To get started, a member of the decision group has to define the decision norms. It is assumed that the chief of the weapon department takes this responsibility. As discussed in Chapter V, the group leader sets different distributed computer-based communications norms. Figure 4 is an actual display screen of the interactive norm definition process.

(4) Decision making procedures:

The evaluation process is broken down to group members. Each decision member has the exclusive right to assess the alternatives according to the criteria that are related to his expertise.

(5) Evaluation Criteria:

For the sake of simplicity, this example excludes political and economical issues that in real-life situations often play an important role in the selection process. The evaluation criteria are grouped in four sets: 'gun systems', 'electronics', 'engine' and 'cost'. The latter are respectively analyzed by officer chief of the weapon department, the chief of the engineering department and the chief of the electronics department. Such a division of evaluation task is motivated by the fact that each of the officers detains unique expertise their field. Figure 5 lists the criteria chosen for the ship selection problem.

TABLE 6 SPECIFICATIONS OF THE WAR SHIPS

	GERMANY, FEDERAL	NETHERLANDS	UNIT. KINGDOM
TYPE	TYPE 122	TYPE	TYPE 21
DISPL (tons)	3600 - Full load	3050 - Standard 3630 - Full load	3000 - Standard 3700 - Full load
DIMENSION (ft)	130x14.5x6.5	130.5x14.4x6.2	133x15x43
AIRCRAFTS	2 Lynx helicopter with AQS 18 sonar	2 AB 212 ASW helicopters	2 Lynx helicopter
MISSILES	SSM:8 Harpoon SAM:1-8 Sea Spar 2 mult sting launchers;2 RAM ASDM	SSM:4 Harpoon SAM:NATO Sea Sparrow PDMS	SSM :8 Harpoon SAM :Sea wolf VLS
GUNS	1-76mm/62; Breda 105 mm 20 tube rocket laun	2-76 mm/62 Compact	1-4.5 in 55 Mk8 C/WS:2-30 mm Goalkeeper
A/S WEAPONS	4 Mk2 32 torpedo tubes	4 MK2 torpedo fot Mk 46 torp	6 STWS torpedo tubes
MAIN ENGINES	2 GE-LM 2500 Gas Turbines 2 MTU 20V 956 TB92 Diesels	2 Rolls-Royce TM3B Gas Turb 2 Rolls-Royce RM1C Gas Turb.	2 Rolls-Royce SM1A Gas Turb. 4 Paxman Valenta Diesels 2 Gec Electr Mot
SPEED (KNOTS)	30 knots	30 knots	28 knots
RANGE (miles)	4000 at 18 knots	4700 at 16 knots	7800 at 15 knots
COMPLEMENT	204	176	143

TABLE 7 SPECIFICATIONS OF THE WAR SHIPS

FEDERAL, GERMANY

RADAR

1. SURVEILLANCE :	Type 996 , Plessey AWS - 5 plus AWS - 6
2. SEA WOLF GUIDANCE	Two Marcony Type 191
3. NAVIGATION	One Kelvin Huges Type 1007

SONAR

Type 2050 (Bow Mounted)
Type 2031 (Towed array)

UNITED, KINGDOM

RADAR

1. SURVEILLANCE	HSA DA 08
2. FIRE CONTROL	HSA WM 25 and STIR
3. NAVIGATION.	SMA 3RM 20

SONAR

Active Passive Atlas DSQS 21 BZ and BO

NETHERLANDS

RADAR

1. SURFACE SURCH	One DA - 08
2. FIRE CONTROL	One LW - 08 One WM 25 SYSTEM One STIR
3. NAVIGATION	One ZW - 06

SONAR

SQS - 505 Bow Mounted

(6) Individual Prioritization of Evaluation Criteria:

As discussed earlier, Co-oP currently provides two modes for individual prioritization of evaluation criteria. Each group member can choose any combination of these two modes. For this example, the chief of the weapon department, the chief of the engineering department and the chief of the electronics department respectively chose the AHP, direct, and direct methods. Figures 7 to 16 successively display the outputs of the prioritization process of the three decision makers. In order to reduce the numberf evaluation iteration, the criteria that score low values are eliminated (Figure 17).

(7) Individual Evaluation of Alternatives

To support the individual evaluation of alternatives, three methods are supported by Co-oP: direct assessment, AHP and ELECTRE. The results of this process are given in Figures 18 to 22.

(8) Group Result

The group result is displayed in Figure 23. It is a combination of the outcomes generated by three decision makers. Figure 23 suggests that TYPE3 is the best one, with an overall score of .34.

SCENARIO 2: COLLECTIVE ASSESSMENT AT THE STAFF LEVEL

To illustrate the Co-oP ability to handle group decision making situations where division of evaluation tasks does not apply, this scenario is identical to the first one with the exception in that there are only four evaluation criteria. Furthermore, these criteria are used by all decision members for evaluating alternatives.

(1) Decision alternatives: Same as in Scenario 1

(2) Decision makers: Same as in Scenario 1

(3) Decision making norms:

Figure 24 is an actual display screen of the interactive norm definition process.

(4) Decision making procedures:

Unlike in scenario 1, each decision member assesses the alternatives according to all of the criteria that are defined for the problem (See Figure 25).

(5) Evaluation Criteria:

For the sake of simplicity, this example retains only four principal criteria, i.e., 'gun systems', 'electronics', 'engine' and 'cost'.

(6) Individual Prioritization of Evaluation Criteria:

Figures 27 and 28 display the outputs of the prioritization process of the first decision maker. In order to reduce the number of evaluation iteration, the criteria that score low values are eliminated (Figure 29).

(7) Individual Evaluation of Alternatives

The results of this process are given in Figures 30 to 41.

(8) Group Result

The group results are displayed in Figure 24 (computed by the Direct Mode) and Figure 25 (computed by ELECTRE). With the direct mode, TYPE 2 is first in all aggregation of preferences techniques, including the sums-of-the-ranks, the additive ranking, the multiplicative ranking and the sum-of-outranking-relations. This result is confirmed by the ELECTRE mode. Note that in the latter mode, only the sums-of-the-ranks and sums-of-outrankings relations are computed.

IX. CONCLUSIONS

This thesis was concentrated on the extension of a the Co-oP decision support system for multiple criteria group decision making. The development focused in the creation of a computer-based communications framework for supporting decision making situations that are distributed in time and in space. The software is written in Pascal and is operational in a network of three personal computers.

A naval warship selection problem was discussed to illustrate the usefulness of the implemented group decision support system.

However, the proposed decision suppport system can only be applied to a certain class of decision situations. In effect, the decision makers are assumed to be cooperative, and knowledgeable about multiple criteria decision making.

APPENDIX A

THE PROGRAM LISTING

```
PROGRAM GDSS ( INPUT , OUTPUT ) ;

{$v-,r-}

LABEL

  normdef,back,solve1,solve2,solve3,
  telos , create ,gdss1,nai, 10 , 20 , 30  ;

CONST

  size         =  25 ;
  position1    =  5  ;
  position2    =  13 ;
  position3    =  21 ;
  maxcrit1     =  5  ;
  maxcrit2     =  5  ;
  maxcrit3     =  5  ;
  windows      =  3  ;
  number        : array[1..Windows,1..4] of Integer
                = (( 2,  2, 78, 13  ) ,
                   ( 2, 15, 78, 21  ) ,
                   ( 2  23, 78, 24  ) ) ;
 TYPE

  name      = string [size] ;
  ask       = string [5];
  color     = string [28] ;
  num2      = array [1..Maxcrit1,1..Maxcrit1] of integer ;
  level     = array [1..Maxcrit1,1..Maxcrit1] of name ;
  vectors   = array [1..Maxcrit1,1..Maxcrit1] of real ;
  matrix20 = array [1..20,1..20 ] of real ;
  aray1     = array [1..9,1..9] of real ;
  Title     = array [1..Maxcrit1] of   name ;
  num1      = array [1..Maxcrit1] of   integer ;
  vectors1 = array [1..Maxcrit1] of   real ;
  vectorg   = array [1..125] of   name ;
  vectorn   = array [1..125] of   real ;
  vectorf   = array [1..20] of   real ;
  title1    = array [1..20] of   name ;
  name2     = array [1..6] of name ;
  array9    = array[1..9,1..9] of char ;
  elpida    = array[1..4] of char ;
 Case1      =  record

     name1   : name   ;
     numofproblem, levels,
     numofalternatives ,numofusers   : integer ;
     level2, level3, level4, level5,

     level6, level7 :   level ;
     level1 :  title ;
     sublevel1 :  num1 ;
     sublevel2 :  num2 ;
     alternatives :  title1 ;

   end (* record *) ;


  case2     = record

     pfactor, qfactor : real ;
     numofcriteria : integer ;
     numofalternatives : integer ;
     alternatives : title1 ;
     numofusers : integer ;
     solved : array [1..3] of boolean ;
     grading     : aray1 ;
     Completed   : boolean ;
     completedall : boolean ;
     vector1  : vectors1 ;
     vector2, vector3, vector4,
     vector5, vector6, vector7 :  vectors ;
     normvector1 : vectorg ;
     normvector2 : vectorn ;
     normindex : vectorg ;
     altmatrix : matrix20 ;
     finalindex : array[1..3] of boolean ;
     Finalindex1 : array[1..3] of boolean ;
     Ahp : record
           status : boolean ;
           altvector1 : vectorf ;
           numoftries : integer ;
     end ;
     electre : record
           status : boolean ;
           outranking : array9  ;
           numoftries : integer ;
     end ;

end ;(* record *)

solution1   =  record
      username : name    ;
```

```
        userid : name ;
        numofcriteria : integer ;
        normvector1 : vectorg ;
        normvector2 : vectorn ;
        numofalternatives : integer ;
        alternatives : title1  ;
      ahp  :  record
          status : boolean ;
          numoftries : integer ;

          altvector1 : vectorf ;

      end ;
      electre :  record
          status : boolean ;
          numoftries : integer ;
          outranking : array9 ;
       end ;

   end ; (* record *)

  norm1      =  record

      numofusers ,
      modifytimes,
      lasttime : integer  ;
      usersnames : name2     ;
      specindex : title   ;
      usersids : name2    ;
      weight : vectors1 ;
      currentname : name      ;
      agregation,
      nai,
      specialized,
      broadcasting,
      modify : boolean ;
      agregationname : elpida  ;

end ; (* record *)


VAR

   problemfile : file of case1 ;
   problem ,problema : case1 ;
   specfile : file of  case2 ;
   specfile2,specfile1 : case2 ;
   solution,solutiona : solution1 ;
   solutionfile : file of solution1 ;
   norm,norma : norm1 ;
   normfile : file of norm1 ;
  basicfile : text ;
  axz,a,b,c,a1,b1,c1,numberx ,
  s1,s2,s3,a5,p3,ax,d1,ab,
  w,e,i,j,k,l,f,code,aa,
  line,position,levels,mal1 ,
  numofalternatives,x1,y1,code1,
  mal2,count,numofcriteria,counttimes : integer ;
  precent,sum,integer1,score,row1 : real ;
  array2 : title ;
  alternatives1 ,alternativesx : title1 ;
  extension,prname1,pruser,answer ,
  normname,answer1,namex,idx,
  problname,methodx,prname,pruser3,specname : name ;
  vector2,vector3,vector4,
  vector5,vector6,vector7 : vectors ;
  altmatrix : matrix20 ;
  vector1,vectortan : vectors1 ;
  altvectorx,altvector,altvector1 : vectorf ;
  choice,ch : char ;
  answer2 : ask ;
  color1,criteria1,criteria2 : color ;
  array1 : num1 ;
  matrix1,result : num2 ;
  normvector1,exchange1 : vectorg ;
  normvector3,normvector2,exchange2 : vectorn ;
  error : boolean ;
  string128,string129 : string[128] ;
  inte : string[10] ;
  index,index2 : boolean ;

  {$I DIRLIST1.PAS}
  {$I DIRLIST2.PAS}
  {$I PROCED.PAS}
  {$I STEP1.PAS}
  {$I FILES.PAS}
  {$I STEP6.PAS}
  {$I STEP2.PAS}
  {$I STEP3-1.PAS}
  {$I STEP2-1.PAS}
  {$I STEP3-2.PAS}
  {$I STEP4-1.PAS}
  {$I STEP4-2.PAS}
  {$I UTILITES.PAS}
  {$I STEP3.PAS}
  {$I STEP4.PAS}

BEGIN (*  main program  *)

  back:
  window ( 1,1,80,23) ;
  textbackground ( 14 ) ;
```

```
 clrscr ;
 window ( 1,24,80,25) ;
 textbackground ( white ) ;
 clrscr ;
 textcolor ( black ) ;
 gotoxy ( 2,1 ) ;
 write ( 'multiple criteria group dss - main menu ' ) ;
 window ( 1,1,80,23) ;
 textcolor ( blue ) ;
 textbackground ( 14 ) ;
 gotoxy ( 3 , 2 ) ;
 write (  '   main menu ' ) ;
 gotoxy ( 3,4 ) ;
 write ('1. Multiple criteria group problem definition');
 gotoxy ( 3,6 ) ;
 write (  '   2. Group norm definition ' ) ;
 gotoxy ( 3,8) ;
 write ( '3. Prioritization of evaluation criteria ' ) ;
 gotoxy ( 3,10 ) ;
 write (  '4. Individual evaluation of alternatives ' ) ;
 gotoxy ( 3,12 ) ;
 write (  '   5. Direct input of the data ' ) ;
 gotoxy (3,14) ;
 write (  '   6. Computation of group decision ' ) ;
 gotoxy (3,16) ;
 write ('7. Identification of negotiable alternatives ' ) ;
 gotoxy ( 3,18 ) ;
 write ('   8. Help ' ) ;
 gotoxy(3,20) ;
 write (  '   9. Exit ' ) ;
 textcolor ( black ) ;
 repeat
   gotoxy ( 3,22) ;
   clreol ;
   write ('   enter a number : ' ) ;
   read ( answer ) ;
   val ( answer,count,code ) ;
 until (( 0 < count) and ( count < 10 ) and ( code = 0 )) ;

 case  count  of

 1:  goto  create  ;
 2:  goto  normdef ;
 3:  goto  solve1  ;
 4:  goto  solve2  ;
 5:  goto  solve3  ;
 6:  goto  gdss1   ;
 7:  goto  nai     ;
 8:  goto  back    ;
 9:  goto  telos   ;
end ;
```

```
 (* problem definition *)

create:

string128 := ' step 1 : problem definition ' ;
diskstatus ;
createproblem ( problem ) ;

(* corect the data of the problem *)
 window ( 1,1,80,17) ;
 textbackground ( blue ) ;

 clrscr ;
 textcolor ( white ) ;

 display ( problem ) ;

 window ( 1,18,80,23 ) ;
 textbackground ( 14 ) ;
 clrscr ;

 window ( 1,24,80,25 ) ;
 textbackground ( white ) ;
 clrscr ;
 textcolor ( black ) ;

 gotoxy ( 2,1) ;
 write ('step 1: multiple criteria group problem
         definition ' );
 gotoxy ( 2,2) ;
 write ( ' correct the data of the problem ' ) ;

 window ( 1,18,80,23 ) ;
 textbackground ( 14 ) ;
 clrscr ;
 textcolor ( black ) ;

 correctdata( problem )   ;
 clrscr ;
 window ( 1,1,80,17) ;
 textbackground ( blue ) ;
 clrscr ;
 textcolor ( white ) ;
 display1 ( problem );

 window ( 1,18,80,23 ) ;
 textbackground ( 14 ) ;
 clrscr ;
 textcolor ( black ) ;

 correctdata1 (problem ) ;
 openfile ( prname ) ;

 writeproblemfile ;

 goto back  ;

(* norm definition *)

 normdef:

 string128 := ' step 2 : normdefinition ' ;
 diskstatus ;

 normdefinition ;

 opennormfile ( normname  ) ;

 writenormfile ;

 goto back ;


(* priority of criteria *)

 solve1:

 priorityofcriteria ;

 goto back ;

(* evaluation of alternatives *)

 solve2:

 computealternatives ;

 goto back ;

(* direct input of the data *)

 solve3:

 string128 :=  'step 5 : direct input of the weights';
 diskstatus ;
 clrscr ;
 window ( 1,24,80,25) ;
 textcolor ( black ) ;
 textbackground ( white ) ;
 gotoxy ( 2,2) ;
 clreol ;
 write ( ' identification of the problem ') ;
```

```
window ( 1,13,80,23) ;
textbackground ( 14 );
clrscr ;

read1 ;

readproblemfile ;

read2 ;

readnormfile ;

read3 ;

if ( not exist (pruser) ) then
begin
 solution.ahp.status := false ;
 solution.electre.status := false ;
 solution.ahp.numoftries := 0 ;
 solution.electre.numoftries := 0 ;
 Opensolutionfile ( pruser )
end ;

readsolutionfile ;

numofcriteria := solution.Numofcriteria ;
numofcriteria := solution.Numofcriteria ;
normvector1   := solution.Normvector1   ;
normvector2   := solution.Normvector2   ;

read4 ;

writenormfile ;

countimes := solution.Ahp.Numoftries ;
if norm.Modify then
begin
  if countimes < norm.Modifytimes  then
  begin
     countimes := countimes  + 1  ;
     index := true ;
     solvewithahp ;
   end
   else
   begin
     clrscr ;
     gotoxy ( 5,9) ;
     write ( 'you cant modify your output ' ) ;
     gotoxy ( 5,10 );
     write ( 'hit any key to continue ') ;
     read ( kbd,ch ) ;
```

```
      goto back ;
    end;
end
else
begin
   if countimes = 0   then
   begin
     countimes := countimes  + 1 ;
     index := true ;
     solvewithahp ;
     clrscr   ;
   end
   else
   begin

     clrscr ;
     gotoxy ( 5,9) ;

     write ( 'you cant modify your output ' ) ;
     gotoxy ( 5,10 );
     write ( 'hit any key to continue ') ;
     read ( kbd,ch ) ;
     goto back ;
   end;
end ;

goto back ;

(*  gdss *)

gdss1:

string128 := 'step 5 : computation of group result   ' ;
string129 := ' ' ;
diskstatus ;

data ;

readproblemfile ;
if norm.specialized  Then
begin
    if ( not exist( specname ) )  then
    begin
       clrscr ;
       gotoxy( 2,2 ) ;
       write ( 'the problem is not yet solved ' ) ;
       gotoxy( 2,4 ) ;
       write ( 'hit any key to continue ' ) ;
       read (kbd ,ch) ;
       goto back ;
    end ;
```

```
readspecfile ;

if ((specfile2.Completedall) and
    (specfile2.electre.Status)) then
begin
  window (1,1,80,23) ;
  textbackground ( blue ) ;
  clrscr ;

  window (1,24,80,25) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy ( 2,1) ;
  write ( 'step 6 : computation of group decition ' ) ;

  gotoxy ( 2,2) ;
  write ( 'final result (electre) - specialized mode ' ) ;
  window (1,1,80,23) ;

  textbackground ( blue ) ;
  clrscr ;
  textcolor ( white ) ;

  for a := 1 to specfile2.Numofalternatives  do
  begin
   answer := specfile2.Alternatives[a] ;
   delete ( answer,4,length( answer ) ) ;
   gotoxy( 2,a + 3) ;
   write ( answer:4 ) ;
  end ;

  for a := 1 to specfile2.Numofalternatives  do
  begin
    answer := specfile2.Alternatives[a] ;
    delete ( answer,4,length( answer) ) ;
    gotoxy ( 5 + ( a * 5 ) , 3 ) ;
    write ( answer:3 ) ;
  end ;

 for a := 1 to specfile2.Numofalternatives do
 begin
  for b := 1 to specfile2.Numofalternatives do
  begin
    gotoxy ( 5 + ( b * 5) , a + 3 ) ;
    write (specfile2.Electre.Outranking[a,b] ) ;
  end ;
end ;
 textcolor ( green ) ;
 gotoxy ( 5,10 ) ;
 write ('**  an outranking relation * is the  ' ) ;
```

```
    gotoxy ( 5,11 ) ;
    write ('     one that satisfies both concordance  ') ;
    gotoxy ( 5,12 ) ;
    write ('     and discordance requirements. ');
    Gotoxy ( 5,13 ) ;
    write ('**  an  -  indicates that there is  ' );
    gotoxy ( 5,14 ) ;
    write ('     no outranking relations.  ' ) ;
    Gotoxy ( 5,16 ) ;
    write ( 'hit any key to continue ' ) ;
    read ( kbd,ch ) ;
 end ;

 if ((specfile2.Completedall )  and  (specfile2.Ahp.Status ))
 then
   begin
     altvector1 := specfile2.Ahp.Altvector1 ;

     window (1,1,80,23) ;
     textbackground ( blue ) ;
     clrscr ;
     window (1,24,80,25) ;

     textbackground ( white ) ;
     clrscr ;
     textcolor ( black ) ;
     gotoxy ( 2,1) ;
     write ( 'step 6 : computation of group decition ' ) ;
     gotoxy ( 2,2) ;
     write ( 'final result (ahp) - specialized mode ' ) ;

     window (1,1,80,23) ;
     textbackground ( blue ) ;
     clrscr ;
     textcolor ( white ) ;

     gotoxy ( 2,3 ) ;
     write ( ' final solution ' ) ;

     for a1 := 1 to problem.Numofalternatives  do
     begin
       textcolor ( white ) ;
       gotoxy ( (  ( 5 *  a1 )) , 19  ) ;
       write ( copy( problem.Alternatives[a1],1,3) ) ;
       gotoxy ( (  ( 5 *  a1 )) , 20  ) ;
       textcolor ( red ) ;
       write ( altvector1[a1]:3:2 ) ;
     end ;

     textbackground ( red ) ;
    for a1 := 1 to  problem.Numofalternatives do
    begin
      gotoxy ( (5 + ( 5 * a1 )) ,17 ) ;
      for b1 := 1 to  round( altvector1[a1] * 10 )  do
      begin
        gotoxy ( ( ( 5 * a1 )) ,(17 -b1) ) ;
        write ( '    ') ;
      end ;
   end ;

   textbackground ( blue ) ;
   gotoxy ( 2,22) ;
   write ( 'hit any key to continue ' ) ;
   read ( kbd ,ch ) ;
end
else
  clrscr ;
  gotoxy( 2,2 ) ;
  write ( 'the problem is not yet solved ' ) ;
  gotoxy( 4,2 ) ;

end
else
  gdss  ;

goto back ;

(*  nai *)

nai:

    (* not avaiable yet *)

goto back ;

telos:

END . (* MAIN PROGRAM *)
```

INCLUDE FILE STEP1

```
PROCEDURE CREATEPROBLEM ( var  problem : case1 ) ;

LABEL
    10, 20 ,30 ;
VAR
  axz : integer ;
  str1,str2 : name ;
  code1 : integer ;
```

```
BEGIN

  textmode ( c80 ) ;
  clrscr ;
  gotoxy ( 1,2) ;
  clear1(problem  ) ;
  problem.Levels := 0 ;
  for c := 1  to 5  do
      problem.Sublevel1[c]:= 0 ;
  for c := 1 to 5 do
  begin
    for b := 1 to 5  do
        problem.Sublevel2[c,b] := 0 ;
  end ;
  textbackground ( black ) ;
  textcolor ( white ) ;

  window ( 1,1,80,23) ;
  textbackground ( 14 ) ;
  clrscr ;

  window ( 1,24,80,25) ;
  textbackground ( white ) ;

  clrscr ;
  textcolor ( black ) ;
  gotoxy(2,1) ;
  write ('step  1 : multiple criteria group problem
definition ');
  gotoxy(2,2 ) ;
  write ( 'definition of alternatives * hit q to stop ' ) ;
  window ( 1,1,80,23) ;
  textbackground ( 14 ) ;
  clrscr ;
  gotoxy ( 2,2 ) ;
  textcolor ( black ) ;
  write ( ' enter the name of the problem  : ') ;
  read ( answer ) ;
  prname1 := answer ;
  delete(answer,8,length(answer) ) ;
  prname := concat(answer ,'.Def' ) ;

  problem.Name1 := answer ;

  gotoxy ( 1,2);
  clreol ;
  gotoxy ( 3,2 ) ;
  write ('  name of problem  :  ', answer ) ;
  line :=  4 ;
  a :=  0 ;
  b :=  0 ;
  w :=  1 ;
  position :=  1 ;
  c := 0 ;
  gotoxy (1,line ) ;
  clearscreen ( line ) ;

  gotoxy ( 3,4 ) ;
  write ( '      enter the alternatives     : ' ) ;
  a5 := 0 ;
  while ((  answer <> 'q') and ( a5 < 19 ) )    do
  begin
    gotoxy ( 42,( 4 + a5   ) )   ;
    a5 := a5 + 1 ;
    write ( '   ',a5,'.   ' ) ;
    Read ( answer ) ;
    answer := stupcase(answer) ;
    problem.Alternatives [a5] := answer ;
  end ;
  problem.Numofalternatives := a5-1 ;
  for a5 := 1 to  10 do
  begin
   gotoxy ( 1, a5 + 2 ) ;
   clreol ;

  end ;
  window ( 1,24,80,25) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy(2,1) ;
  write ('step 1 : multiple criteria group problem
definition ');
  gotoxy(2,2 ) ;
  write ('definition of criteria *  1)st level 2)nd level
          3)nd level q)uit' ) ;

  window ( 1,1,80,23) ;
  textbackground ( 14 ) ;
  textcolor ( black ) ;
  repeat
    gotoxy ( 3,line ) ;
    write ( '      enter the number of the level   : ' ) ;
    read ( answer ) ;
    answer := stupcase(answer) ;

    line := 4 ;
    delline  ;
  until (answer = '1') or (answer = '2) or (answer = '3') ;
  while answer <> 'q' do
  begin
    clearscreen ( line ) ;
    if  answer = '1'   then
    begin
      gotoxy(5,line) ;
      clreol ;
10 :
      position := position1 ;
      clearscreen ( line ) ;
      textcolor (blue) ;
      gotoxy(position,line) ;
      textcolor (blue ) ;
      write (a+ 1,'.' ) ;
      Gotoxy(position + 3 , line );
      read ( answer );
      answer := stupcase(answer) ;
      if ( answer  <> '2' ) and ( answer <> '3' )
          and ( answer <> q')and (answer <>'1')        then
      begin
        a := a + 1 ;
        problem.Level1[ a ] := answer ;
        line := line + 1 ;
        b := 0 ;
        goto 10
      end ;
    end ;
    problem.levels := a ;
    If answer = '2'  then

    begin
      gotoxy ( 5,line ) ;
      clreol ;
      textcolor ( 14 ) ;
      position := position2 ;
20 :  clearscreen ( line ) ;
      textcolor ( red ) ;
      gotoxy ( position,line ) ;
      write (a,'.',b+1 );
      Gotoxy ( position + 5 , line );
      read ( answer ) ;
      answer := stupcase(answer) ;
      if ( answer  <> '1' ) and ( answer <> '3' )
         and ( answer <> 'q')   and ( answer <>'2')   then
      begin
        b := b + 1 ;
        problem.Level2 [ a,b ] := answer ;
        line := line + 1 ;
        c := 0  ;
        goto 20 ;
      end ;
    end;
    problem.Sublevel1[a] := b ;
    if answer = '3' then
    begin
      gotoxy(5,line ) ;
      clreol ;
      textcolor ( yellow ) ;
      position := position3 ;
 30 : clearscreen ( line ) ;
      textcolor ( yellow ) ;
      gotoxy ( position,line ) ;
      write  (a,'.',b,'.',c+1 ) ;
      Gotoxy (position +7 , line ) ;
      read ( answer ) ;
      answer := stupcase(answer);
      while answer = '3' do
      begin
        gotoxy ( position +7 , line ) ;
        clreol;
        read ( answer ) ;
        answer := stupcase(answer);
      end;
      if ( answer <> '2' ) and ( answer <> '1' )
          and ( answer <> 'q')                            then
      begin
        c := c +1 ;
        case  a   of
          1 : problem.Level3[b,c]  := answer ;
          2 : problem.Level4[b,c]  := answer ;
          3 : problem.Level5[b,c]  := answer ;
          4 : problem.Level6[b,c]  := answer ;
          5 : problem.Level7[b,c]  := answer

        line := line + 1 ;
        goto 30
      end ;
    end ;
    problem.Sublevel2[a,b] := c ;
  end;

  window (1,1,80,25 ) ;
  clrscr ;

END ;


PROCEDURE DISPLAY ( problem : case1 ) ;

VAR

  line , a , b , c ,col1,col2,col3 : integer ;
  change : boolean ;
```

```
BEGIN

   gotoxy(3,1) ;
   textcolor(white );
   line := 2 ;
   col1 := 2 ;
   change := false ;
   for a:=1 to   problem.levels     Do
   begin
     if  ( length(problem.level1[a]) > 1 ) Then
     begin
       textcolor(white) ;
       if  ( line > 14 ) then
       begin
         col1 := col1 + 30 ;
         line := 2 ;
         change := true ;
       end ;
       if  ( ( line > 14 ) and ( change ) ) then
       begin
         col1 := col1 + 60 ;
         line := 2 ;
       end ;
       gotoxy( col1,line ) ;
       writeln (a, '. ',Problem.Level1[a] );
       line:=line+ 1 ;

       for b := 1 to   problem.Sublevel1[a]   do
       begin
         textcolor ( red ) ;
         if (length (problem.Level2[a,b] ) > 1 )  then
         begin

           if  ( line > 14 ) then
           begin
             col1 := col1 + 30 ;
             line := 2;
             change := true ;
           end ;
           if  ( ( line > 14 ) and ( change ) ) then
           begin
             col1 := col1 + 60 :
             line := 2 ;
           end ;
           gotoxy ( col1+1,line ) ;
           write(a,'.',B,'   ', problem.Level2[a,b]);
           line := line + 1 ;

           for c:=1 to problem.Sublevel2[a,b]   do
           begin
             textcolor ( yellow ) ;
```

```
case    a       of
   1: begin
      if (length(problem.Level3[b,c])>1)  then

       begin
          if  ( line > 15 ) then
          begin
            col1 := col1 + 30 ;
            line := 2 ;
            change := true ;
          end ;
          if  ((line>14) and (change)) then
          begin
            col1 := col1 + 60 ;
            line := 2 ;
          end ;
          gotoxy ( col1+2,line ) ;
          write(a,'.',B,'.',C,'   ',
                problem.Level3[b,c]) ;
          line := line + 1 ;
       end ;
     end ;
  2: begin
     if (length(problem.Level4[b,c])>1)  then
     begin
       if  ( line > 15 ) then
       begin
         col1 := col1 + 30 ;
         line := 2 ;
         change := true ;
       end ;
       if  ( ( line > 14 ) and ( change ) ) then
      begin
          col1 := col1 + 60 ;
          line := 2 ;
       end ;
       gotoxy ( col1+2,line ) ;
       write(a,'.',B,'.',C,'   ',
             problem.Level4[b,c]) ;
       line := line + 1 ;
     end ;
   end ;
3: begin
    if (  length( problem.Level5[b,c])>1) then
    begin
       if  ( line > 15 ) then
       begin
         col1 := col1 + 30 ;
         line := 2 ;
         change := true ;
        end ;
        if  ( ( line ) 14 ) and (change))  then
        begin
          col1 := col1 + 60 ;
          line := 2 ;
        end ;
        gotoxy ( col1+2,line) ;

         write(a,'.',B,'.',C,'   ',
              problem.Level5[b,c]) ;
         line := line + 1 ;
      end ;
    end ;
 4: begin
     if ( length(problem.Level6[b,c]) ) 1)  then
     begin
       if  ( line ) 15 ) then
       begin
         col1 := col1 + 30 ;
         line := 2 ;
         change := true ;
       end ;
       if  ( ( line ) 14 ) and ( change ) ) then
       begin
          col1 := col1 + 60 ;
          line := 2 ;
       end ;
       gotoxy ( col1+2,line ) ;
       write(a,'.',B,'.',C,'   ',
             problem.Level6[b,c]) ;
       line := line + 1 ;
     end ;
   end ;
5: begin
     if (  length(problem.Level7[b,c]))1) then
     begin
       if  ( line ) 15 ) then
       begin

         col1 := col1 + 30 ;
         line := 2 ;
         change := true ;
       end ;
       if  ( ( line ) 14 ) and ( change ) ) then
       begin
          col1 := col1 + 60 ;
          line := 2 ;
       end ;
       gotoxy ( col1+2,line ) ;
       write(a,'.',B,'.',C,'   ',
             problem.Level7[b,c]) ;
       line := line + 1 ;
```

```
                 end ;
               end ;
             end ;
           end ;
         end ;
       end ;
     end ;
   end;

 END ;

PROCEDURE DISPLAY1 ( problem : case1 ) ;

VAR
  line : integer ;

BEGIN

  gotoxy(3,2) ;
  textcolor(white );
  write ( 'alternatives : ' ) ;
  for line := 1 to problem.numofalternatives Do
  begin
    gotoxy ( 4,line + 3 ) ;
    write (line,'. ', problem.alternatives[line] ) ;
  end ;

END ;



PROCEDURE CORRECTDATA ( var problem : case1 ) ;

BEGIN

  repeat
    gotoxy ( 1,2 ) ;
    write ('do you want to modify the criteria (y/n) ?  ');
    Repeat
      gotoxy(47,2 ) ;

      clreol ;
      read ( answer ) ;
      answer := stupcase(answer) ;
    until  ( ( answer = 'y') or ( answer = 'n' ) ) ;
    if answer = 'y' then
    begin
      gotoxy(1,4) ;
      write ('enter  the tree level ( e.g.,2.1.3 )  ?' ) ;
      Gotoxy ( 47,4 ) ;
      read (answer2);
      answer2 := stupcase(answer2);
      gotoxy  ( 1,6 ) ;
      write (    ' name of criteria  ', answer2  ) ;
      gotoxy (43,6);
      write ( '?') ;
      Gotoxy(47,6) ;
      read( answer1) ;
      w :=1 ;
      convert ( answer2,w,d1) ;
      a1 := d1 ;
      w := 3;
      convert ( answer2,w,d1) ;
      b1 := d1 ;
      w := 5 ;

      convert ( answer2,w,d1) ;
      c1 := d1 ;

      if  (c1 = 0 ) and (b1 = 0 ) and ( a1 <> 0 ) then
          problem.Level1[a1] := stupcase( answer1) :
      if  ( a1 > problem.levels ) Then
          problem.Levels := problem.Levels + 1 ;
      if  c1 = 0   then
      begin
        problem.Level2[a1,b1] :=  stupcase( answer1) ;
        if ( b1 > problem.Sublevel1[a1] ) then
         problem.Sublevel1[a1] :=  problem.Sublevel1[a1]+1 ;
      end
      else
      begin
        case     a1       of
           1:  problem.Level3[b1,c1] :=  stupcase( answer1);
           2:  problem.Level4[b1,c1] :=  stupcase( answer1);
           3:  problem.Level5[b1,c1] :=  stupcase( answer1);
           4:  problem.Level6[b1,c1] :=  stupcase( answer1);
           5:  problem.Level7[b1,c1] :=  stupcase( answer1);
        end ;
        if ( c1 > problem.Sublevel2[a1,b1] ) then
        problem.Sublevel2[a1,b1] :=problem.Sublevel21,b1]+1;
      end ;
      gotoxy ( 47,2 ) ;
      clreol ;
      gotoxy (47,4 ) ;
      clreol ;
      gotoxy ( 47,6 ) ;
      clreol ;
      a1 := 0 ; b1 := 0 ; c1 := 0 ;
    end;
    until answer = 'n' ;

END ;
```

```
PROCEDURE CORRECTDATA1 ( var problem : case1 ) ;

BEGIN
  repeat
    gotoxy ( 1,2 ) ;
    write ('do you want to modify the alternatives (y/n)?);
    Repeat
      gotoxy(52,2 ) ;
      clreol ;
      read ( answer ) ;
      answer := stupcase(answer) ;
    until  (( answer = 'y') or ( answer = 'n' ) ) ;
    if answer = 'y' then

    begin
      gotoxy(1,4) ;
      write ('enter the number of the alternative(e.g.,3)?')
      Gotoxy ( 53,4 ) ;
      read (answer2);
      answer2 := stupcase(answer2);
      gotoxy  ( 1,6 ) ;
      write (' name of alternative  ', answer2  ) ;
      gotoxy (33,6);
      write ( '?') ;
      Gotoxy(37,6) ;
      read( answer1) ;
      val(answer2,a,code) ;
      problem.alternatives[a] := Stupcase(answer1) ;
      gotoxy ( 47,2 ) ;
      clreol ;
      gotoxy (47,4 ) ;
      clreol ;
      gotoxy ( 47,6 ) ;
      clreol ;
    end ;
  until answer = 'n' ;

END ;
```

INCLUDE FILE STEP2

```
OVERLAY PROCEDURE  NORMDEFINITION ;
VAR
  x1,y1,limit : integer ;
  count3 : real ;
  lasthour : string[22] ;
  problemname1 : name ;
```

```
BEGIN

  window ( 1,1,80,22) ;
  textbackground ( 14 ) ;
  clrscr ;

  window ( 1,24,80,25) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy ( 2,1) ;
  write ( ' step 2 : group norm definition ' ) ;

  window ( 1,1,80,22) ;
  textbackground ( 14 ) ;
  clrscr ;
  textcolor ( black ) ;

  gotoxy ( 2,2) ;
  write ( 'name of the group norm ') ;
  gotoxy ( 25,2);
  write ( '?  ' ) ;
  Read ( answer ) ;
  norm.Currentname := stupcase(answer) ;
  delete ( answer,8,length(answer) ) ;
  normname := concat ( answer , '.Gn' ) ;
  textcolor ( blue ) ;

  gotoxy ( 2,4 ) ;
  write ( '1. Identification of group members  ' ) ;
  textcolor ( black ) ;
  gotoxy ( 5,6) ;
  write (  '1.1  Number of group members ( max 3 ) ' ) ;
  gotoxy ( 52,6 );
  write ( '?  ' ) ;
  Count3 := 0 ;
  x1 := 55 ; y1 := 6 ; limit := 4 ;
  checknumber ( answer , x1,y1,limit,count3 ) ;
  norm.Numofusers := trunc( count3) ;
  for a := 1 to trunc( count3) do
  begin
    gotoxy ( 9,6+a ) ;

    write (' -  name of member   # ' , a ) ;
    gotoxy ( 52,6+a );
    write ( '?  ' ) ;
    Gotoxy ( 55,6+a ) ;
    read ( answer ) ;
    norm.Usersnames[a] := stupcase(answer) ;
  end ;
  gotoxy ( 5,a+7 ) ;
```

```
 write ('1.2  Id of member  ', norm.Usersnames[1] ) ;
 gotoxy ( 52,7+a );
 write ( '?  ' ) ;
 Gotoxy ( 55,a+7) ;
 read ( answer ) ;
 norm.Usersids[1] := stupcase(answer) ;

 gotoxy ( 2,12 ) ;
 textcolor ( blue ) ;
 write ( '2. Group decition techniques  ' ) ;
 textcolor ( black ) ;
 gotoxy ( 5,14 ) ;
 write ( '2.1 Weighted majority rule : ' );
 gotoxy ( 9,15) ;
 write ( '-  equal weights (y/n)' ) ;
 gotoxy ( 52,15 );
 write ( '?  ' ) ;
 X1 := 55 ; y1 := 15 ;
 identify ( answer ,x1,y1 ) ;

 if  answer = 'y' then
 begin
   for a := 1 to norm.Numofusers do
      norm.Weight[a] := 1
 end
 else
 begin
   for a := 1 to norm.Numofusers do
   begin
     gotoxy ( 12,15 + a ) ;
     write ( '-  weight for  ', norm.Usersnames[a] ) ;
     gotoxy ( 52,15+a );
     write ( '?  ' ) ;
     Count3 := 0 ;
     x1 := 55 ; y1 := ( 15 + a ) ; limit := 100 ;
     checknumber ( answer , x1,y1,limit,count3 ) ;
     norm.Weight[a] := count3 ;
   end ;
end ;
clrscr ;

gotoxy ( 5,2) ;
textcolor ( blue ) ;
write ( '2.2 Collective evaluation mode ') ;

gotoxy ( 8,4 ) ;
textcolor ( black ) ;
write ( '    choose one of the following modes : ') ;
gotoxy ( 10,6) ;
write ( '     (1) each group member will evaluates
         alternatives');
```

```
gotoxy ( 10,7) ;
write ( '          according to all criteria.' );
gotoxy ( 10,8) ;
write (  '     (2) Each group member will evaluate only
                  alternatives');
gotoxy ( 10,9) ;
write ('         according to his exclusive area of
         expertise.');
gotoxy ( 8,11) ;
write(    '    Enter a number ? ' ) ;

Count3 := 0 ;
x1 := 31 ; y1 := 11 ; limit := 2 ;
checknumber ( answer , x1,y1,limit,count3 ) ;

if answer = '1' then
   norm.Specialized := false
else
begin
  norm.Specialized := true ;
  a := 0 ;
  repeat
  gotoxy ( 8,13) ;
  clreol ;
  write ( '    the name of the problem ? ' ) ;
  Read ( answer ) ;
  delete ( answer ,8,length(answer) ) ;
  prname := concat ( answer ,'.Def' ) ;
  norm.normnamex := prname ;
  Problemname1 := answer ;
  until exist ( prname ) ;
  readproblemfile ;
  for a:= 1 to problem.Levels  do
  begin
    gotoxy ( 16,14 + a ) ;
    write   ( '- name of user for critiria
           ',problem.Level1[a],'  ? ');
    error := false ;
    repeat
      gotoxy ( 54,14 + a ) ;
      clreol ;
      read ( answer ) ;
      answer := stupcase ( answer ) ;
      for b := 1 to norm.numofusers do
      begin
        if answer = norm.usersnames[b] then
           error := true ;

      end ;
    until error ;
    Norm.Specindex[a] := answer ;
  end ;
 end;
 clrscr ;

 gotoxy ( 5,2) ;
 write ( '2.3 Automatic selection of techniques of ') ;
 gotoxy ( 5,3) ;
 write ( '     aggregation of preference (y/n)') ;
 gotoxy ( 52,3);
 write ( '?  ' ) ;
 X1 := 55 ; y1 := 3 ;
 identify ( answer ,x1,y1 ) ;

 if answer = 'y' then
    norm.Agregation := true
 else
 begin
   norm.Agregation := false ;
   a := 0 ;
   gotoxy ( 9,5) ;
   write (    '- r1 : sum of ranks (y/n)' ) ;
   gotoxy ( 52,5);
   write ( '?  ' ) ;
   X1 := 55 ; y1 := 5 ;
   identify ( answer ,x1,y1 ) ;
   if answer = 'y' then
   begin
     a := a + 1 ;
     norm.Agregationname[a] := '1' ;
   end
   else
   begin
     a := a + 1 ;
     norm.Agregationname[a] := 'e' ;
   end ;
   gotoxy ( 9,6) ;
   write ('- r2 : sum of outranking relations (y/n)' ) ;
   gotoxy ( 52,6);
   write ( '?  ' ) ;
   X1 := 55 ; y1 := 6 ;
   identify ( answer ,x1,y1 ) ;
   if answer = 'y' then
   begin
     a := a + 1 ;
     norm.Agregationname[a] := '2' ;
   end
   else
   begin
     a := a + 1 ;
```

```
      norm.Agregationname[a] := 'e' ;
    end ;
    gotoxy ( 9,7) ;

    write ('- r3 : additive ranking  (y/n)') ;
    gotoxy ( 52,7);
    write ( '?  ' ) ;
    X1 := 55 ; y1 := 7 ;
    identify ( answer ,x1,y1 ) ;
    if answer = 'y' then
    begin
      a := a + 1 ;
      norm.Agregationname[a] := '3' ;
    end
    else
    begin
      a := a + 1 ;
      norm.Agregationname[a] := 'e' ;
    end ;
    gotoxy ( 9,8) ;
    write ('- r4 : multiplicative ranking  (y/n)' ) ;
    gotoxy ( 52,8);
    write ( '?  ' ) ;
    X1 := 55 ; y1 := 8 ;
    if answer = 'y' then
    begin
      a := a + 1 ;
      norm.Agregationname[a] := '4' ;
    end
    else
    begin
      a := a + 1 ;
      norm.Agregationname[a] := 'e' ;
    end ;
end ;
gotoxy ( 5,9) ;
write ( '2.4 Automatic computation of nai (y/n) ' ) ;
gotoxy ( 52,9);
write ( '?  ' ) ;
X1 := 55 ; y1 := 9 ;
identify ( answer ,x1,y1 ) ;
if answer = 'y' then
norm.Nai := true
else
  norm.Nai := false ;
clrscr ;
gotoxy( 2,2) ;
textcolor ( blue ) ;
write ( '3. Information exchange   ' ) ;
textcolor ( black ) ;
gotoxy (5,4) ;
```

```
 write ( '3.1  Broadcasting of individual outputs (y/n)' ) ;
 gotoxy ( 52,4);
 write ( '?  ' ) ;
 X1 := 55 ; y1 := 4 ;
 identify ( answer ,x1,y1 ) ;
 if answer = 'y' then
    norm.Broadcasting := true
 else
 begin
   norm.Broadcasting := false ;
 end ;
 gotoxy ( 5,5) ;
 write ( '3.2 Permission to modify individual analyses ' ) ;
 gotoxy ( 5,6) ;
 write ( '    after group analyses (y/n) ' ) ;
 gotoxy ( 52,6);
 write ( '?  ' ) ;
 identify ( answer ,x1,y1 ) ;
 if answer = 'n' then
    norm.Modify := false
 else
 begin
   norm.Modify := true ;
   gotoxy ( 9,7) ;
   write ( '3.2.1  How many times (max 10 )' ) ;
   gotoxy ( 52,7);
   write ( '?  ' ) ;
   Count3 := 0 ;
   checknumber ( answer , x1,y1,limit,count3 ) ;
   norm.Modifytimes :=trunc( count3) ;
   if norm.Specialized then
      norm.Modifytimes := norm.Modifytimes * norm.Numofusers
 end ;
 gotoxy ( 5,8 ) ;
 write ( '3.3 Time limit to submit individuals results : ' )
 gotoxy ( 9,9) ;
 write ( '3.3.1  How many days (max 14 ) ') ;
 gotoxy ( 52,9);
 write ( '?  ' ) ;
 Count3 := 0 ;
 checknumber ( answer , x1,y1,limit,count3 ) ;
 norm.Lasttime := trunc( count3) ;
 gotoxy ( 9,10) ;
 write ( '3.3.2  Hours ( 1:00 to 24:00 )') ;
 gotoxy ( 52,10);
 write ( '?  ' ) ;
 Gotoxy ( 55,10) ;
 read ( lasthour ) ;
 for a := 2 to norm.Numofusers do
     norm.Usersids[a] := 'X' ;
END ;
```

INCLUDE FILE STEP2-1

```
PROCEDURE NORMSELECTION ( VAR X1,Y1 : INTEGER ) ;

BEGIN

  gotoxy ( x1,y1) ;
  write ( ' name of the norm ? ') ;
  Repeat
    gotoxy ( 23,y1) ;
    clreol ;
    read ( answer ) ;
    norm.Currentname := stupcase(answer) ;
    normname := concat ( answer , '.Gn' ) ;
  until ( exist ( normname ) ) ;

END ;


PROCEDURE DISPLAYNORM ;

VAR
 message1,message2 : string[80] ;

BEGIN

  window ( 1,1,80,25) ;
  textbackground ( blue ) ;
  clrscr ;

  textcolor ( white  ) ;
  readnormfile ;
  clrscr ;
  gotoxy ( 2,2 ) ;
  write ( 'name of the group norm : ',norm.Currentname  ) ;
  gotoxy ( 2,3 ) ;
  write ( '1. Identification of group members   ' ) ;
  gotoxy ( 5,4) ;
  write (  '1.1  Number of group members : ,
 norm.Numofusers) ;
  for a := 1 to norm.Numofusers do
  begin
    gotoxy ( 9,4+a ) ;
    write (' -  name of member  # ' , a , ' : ',
            norm.Usersnames[a] ) ;
  end ;
  gotoxy ( 2,9 ) ;
  write ( '2. Group decision techniques  ' ) ;
  gotoxy ( 5,10 ) ;
  write ( '2.1 Weighted majority rule ' );
  gotoxy ( 9,11) ;
  write ( '-  weights of members :  ' ) ;
  for a := 1 to norm.Numofusers do
  begin
    gotoxy ( 12 , 11 + a ) ;
    write      (      a,'.     ',Norm.Usersnames[a],'      :,
norm.Weight[a]:4:2 );
  end ;

 if norm.specialized  then
 begin
   message1 := ' Each group member will evaluate only
          alternatives' ;
   message2  :=   '  according  to  his  exclusive  area  of
expertise';
 end
 else
 begin
   message1  :=   '   each   group   member   will   evaluate
alternatives' ;
   message2 := ' according to all criteria';
 end ;

 gotoxy ( 5,15) ;
 write ( '2.2 Collective evaluation mode : ')  ;
 gotoxy ( 9,16) ;
 write ( message1 ) ;
 gotoxy ( 9,17) ;
 write ( message2 ) ;

 if norm.specialized then
 begin
   prname := norm.normnamex ;
   readproblemfile ;
   gotoxy(11,18); write ( 'Criteria' ) ;
   gotoxy(35,18); write ( 'user name' ) ;
   for a := 1 to problem.levels  do
   begin
     gotoxy ( 11,18 + a ) ;
     write  ( problem.level1[a] ) ;
     gotoxy ( 35,18 + a ) ;
     write  ( norm.specindex[a] ) ;
   end ;
 end ;
 Textcolor ( red ) ;
 gotoxy ( 2,25) ;
 write ( ' hit any key to continue   ' ) ;
 read ( kbd , ch ) ;
 clrscr ;
 textcolor ( white ) ;
 gotoxy ( 5,3 ) ;
 write (  '2.3 Selection of techniques of aggregation of
         preference : ') ;
 if  norm.Agregation   then
 begin
   gotoxy ( 65,3) ;
   write ( ' r1 r2 r3 r4 ' ) ;
 end
 else
 begin
   gotoxy ( 60,3) ;
   for  a := 1 to 4 do
   begin
     case  norm.Agregationname[a] of
           '1': write ( 'r1 ' ) ;
           '2': write ( 'r2 ' ) ;
           '3': write ( 'r3 ' ) ;
           '4': write ( 'r4 ' ) ;
     end ;
   end ;
 end ;

 gotoxy ( 5,5) ;
 write ( '2.4 Automatic computation of nai : ' ) ;
 if   norm.Nai then
      write ( 'yes ' )
 else
   write ( 'no ' ) ;
 gotoxy( 2,8) ;
 write ( '3.  Information exchange   ' ) ;
 gotoxy ( 5,9) ;
 write ( '3.1 Broadcasting of individual outputs : ' ) ;
 if norm.Broadcasting  then
    write ( 'yes  ' )
 else
    write ( 'no ' ) ;
 gotoxy ( 5,10) ;
 write ( '3.2 Permission to modify individual analysis after
group analysis : ' ) ;
 if norm.Modify  then
 begin
   writeln  ( 'yes ' ) ;
   write ( '        you can modify the output  ',
   norm.Modifytimes,' times ' ) ;
 end
 else
   write ( 'no ' ) ;
 gotoxy ( 5,12) ;
 write ( '3.3 Time limit to submit individual results:') ;
 gotoxy ( 9,13 ) ;
 write (  'date : ' , norm.Lasttime ) ;
 gotoxy ( 9,14 ) ;
 write ( 'hour : ' , '22:30' ) ;
 textcolor ( red ) ;
 gotoxy ( 2,25) ;
 write ( ' hit any key to continue  ' ) ;
 read ( kbd , ch ) ;

END ;
```

INCLUDE FILE STEP3

```
PROCEDURE PRIORITYOFCRITERIA ;

LABEL

  telosx,telosx1,telosx2 ;

VAR

  pruser1,filename2 : name  ;
  error5 : boolean ;

PROCEDURE FINALWEIGHTS ;

BEGIN

  for a := 1  to  problem.Levels  do
  begin
    for b := 1 to problem.Sublevel1[a]  do
    begin
      vector2[a,b] := vector2[a,b] * vector1[a] ;
      for  c := 1 to   problem.Sublevel2[a,b]  do
      begin
        case     a     of
          1:   vector3[b,c] := vector3[b,c] * vector2[a,b] ;
          2:  vector4[b,c] := vector4[b,c] *  vector2[a,b] ;
          3:   vector5[b,c] := vector5[b,c] * vector2[a,b] ;
          4:  vector6[b,c] := vector6[b,c] *  vector2[a,b] ;
          5:   vector7[b,c] := vector7[b,c] * vector2[a,b] ;
       end ;
      end ;
      c := 0 ;
    end ;
    b := 0 ;
  end ;
END ;
```

```
PROCEDURE FINALCRITERIA1 ;

BEGIN

  numofcriteria := 1 ;

  selectcriteria ( problem, vector1, vector2, vector3,
                   vector4, vector5, vector6, vector7,
                   normvector1, normvector2, numofcriteria   );
  numofcriteria :=  ( numofcriteria - 1 ) ;

  sort1 ( normvector1 , normvector2 , numofcriteria ) ;

  finalcriteria (normvector1, normvector2, numofcriteria   ) ;
  solution.Numofcriteria   := numofcriteria ;
  solution.Normvector2     := normvector2 ;
  solution.Normvector1     := normvector1   ;

  solution.Username        := namex ;
  if ( not norm.specialized ) Then
  begin
    if ( not exist( pruser ) )  then
    begin
      solution.Ahp.Status       := false ;
      solution.Electre.Status := false ;
      solution.Ahp.Numoftries := 0 ;
      solution.Electre.Numoftries := 0 ;
      opensolutionfile ( pruser ) ;
    end ;
    writesolutionfile ;
  end ;
END ;


BEGIN (* main *)

  string128 := 'step 3:prioritization of evaluation
       criteria';
  diskstatus ;
  string129 := 'identification of the problem methods :
                 ahp or direct';
  data ;
  writenormfile ;
  read5 ;
  readproblemfile ;
  clrscr ;
  if norm.Specialized then
  begin
    if ( not exist( pruser3 ) )  then
    begin
      error5 := false ;
    for a := 1 to 3 do
    begin
      specfile2.solved[A]     := false ;
      specfile2.Finalindex[a] := false ;
    end ;
    specfile2.completed     := False ;
    specfile2.Completedall  := false ;
    openspecfile ( pruser3 ) ;
    writespecfile ;
  end
  else
    error5 := true ;
  readspecfile ;
  vector1 := specfile2.vector1 ;
  vector2 := specfile2.vector2 ;
  vector3 := specfile2.vector3 ;
  vector4 := specfile2.vector4 ;
  vector5 := specfile2.vector5 ;
  vector6 := specfile2.vector6 ;
  vector7 := specfile2.vector7 ;

  b := 0 ;
  repeat
    b := b + 1 ;
  until ( namex = norm.usersnames[b] ) ;
  specfile2.solved[b] := true ;
end ;

If methodx = 'ahp'  then
   evaluate (problem.Level1,problem.Levels,vector1 )
else
   direct1 (problem.Level1,problem.Levels,vector1 ) ;
clrscr ;

if  ( ( norm.specialized ) And ( error5) ) then
begin
  for  a := 1 to problem.levels Do
    vector1[a] := ( vector1[a] + specfile2.vector1[a] )/2;
end ;
for  mal1 :=1 to problem.Levels do
begin
  if norm.Specialized then
  begin
    if norm.Specindex[mal1] <>  namex  then
       goto telosx ;
  end ;
  for  mal2  := 1 to problem.Sublevel1[mal1]  do
  begin
    vectortan[mal2] := vector2[mal1,mal2] ;
    array2[mal2]    := problem.Level2[mal1,mal2] ;
  end ;
```

```
    if methodx = 'ahp'  then
     evaluate (array2,problem.Sublevel1[mal1],vectortan)
    else
     direct1(array2,problem.Sublevel1[mal1],vectortan ) ;
    mal2 := 0 ;
    for mal2 := 1  to  problem.Sublevel1[mal1] do
    begin
      if norm.Specialized then
      begin
        if norm.Specindex[mal1] <>  namex  then

           goto telosx ;
      end ;
      vector2[mal1,mal2] := vectortan[mal2] ;
    end ;
    mal2 := 0 ;
telosx:
  end ;

  clrscr ;

  for s1 := 1 to problem.Levels do
  begin
    if norm.Specialized then

   begin
      if norm.Specindex[s1] <>  namex  then
         goto telosx1 ;
    end ;
    for s2 := 1 to problem.Sublevel1[s1]   do
    begin
      for s3 := 1 to problem.Sublevel2[s1,s2]  do
      begin
        case    s1     of
           1: begin
                array2[s3]      :=  problem.Level3[s2,s3]   ;
              vectortan[s3] :=  vector3[s2,s3] ;
               end ;
           2: begin
                array2[s3]     :=  problem.Level4[s2,s3]    ;
              vectortan[s3] :=  vector4[s2,s3] ;
               end ;
           3: begin
                array2[s3]      :=  problem.Level5[s2,s3]   ;
              vectortan[s3] :=  vector5[s2,s3] ;
               end ;
           4: begin
                array2[s3]     :=  problem.Level6[s2,s3]    ;
              vectortan[s3] :=  vector6[s2,s3] ;
               end ;
           5: begin
```

```
                array2[s3]     :=  problem.Level7[s2,s3]  ;
              vectortan[s3] :=  vector7[s2,s3] ;
               end ;
        end ;
      end ;
      s3 := 0 ;
      if methodx = 'ahp'  then
         evaluate(array2,problem.Sublevel2[s1,s2],vectortan)
      else
       direct1(array2,problem.Sublevel2[s1,s2],vectortan);
      clrscr ;

      for s3 := 1 to problem.Sublevel2[s1,s2]  do

      begin
        if norm.Specialized then
        begin
          if norm.Specindex[s1]  <>  namex  then
             goto telosx ;
        end ;

        case    s1     of
           1 : vector3[s2,s3]  :=  vectortan[s3]  ;
           2 : vector4[s2,s3]  :=  vectortan[s3]  ;
           3 : vector5[s2,s3]  :=  vectortan[s3]  ;
           4 : vector6[s2,s3]  :=  vectortan[s3]  ;
           5 : vector7[s2,s3]  :=  vectortan[s3]  ;
        end ;

     end ;
    end ;
    s2 := 0 ;
telosx1:
  end ;

  if ( not norm.Specialized ) then
  begin
    finalweights ;
    finalcriterial ;
  end
  else
  begin
    specfile2.vector1 := vector1 ;
    specfile2.vector2 := vector2 ;
    specfile2.vector3 := vector3 ;
    specfile2.vector4 := vector4 ;
    specfile2.vector5 := vector5 ;
    specfile2.vector6 := vector6 ;
    specfile2.vector7 := vector7 ;
    writespecfile ;
  end ;
```

```
if norm.specialized then
begin
  readspecfile ;
  mal1 := 0 ;
  for a :=1 to 3 do
  begin
    if specfile2.solved[a] then
       mal1 := mal1 + 1 ;
  end ;

  if mal1 =  norm.numofusers  then
  begin
    vector1 := specfile2.vector1 ;
    vector2 := specfile2.vector2 ;

    vector3 := specfile2.vector3 ;
    vector4 := specfile2.vector4 ;
    vector5 := specfile2.vector5 ;
    vector6 := specfile2.vector6 ;
    vector7 := specfile2.vector7 ;
    finalweights ;
    finalcriteria1 ;
    specfile2.completed   := true ;
    specfile2.normvector1 := normvector1 ;
    specfile2.normvector2 := normvector2 ;
    for a := 1 to numofcriteria do
    begin
      for mal1 := 1 to problem.levels do
      begin
        if  problem.level1[mal1] = normvector1[a] then
        begin
          specfile2.normindex[a] := norm.specindex[mal1] ;
          goto telosx2 ;
       end ;
     end ;
     for mal1 := 1 to problem.levels do
     begin
       For mal2 := 1  to  problem.sublevel1[Mal1] do
       begin
        if problem.level2[mal1,mal2] = normvector1[a] Then
        begin
         specfile2.normindex[a] :=  norm.specindex[mal1] ;
         goto telosx2 ;
         end ;
       end ;
     end;

     For s1 := 1 to problem.Levels do
     begin
       for s2 := 1 to problem.Sublevel1[s1]   do
       begin
```

```
           for s3 := 1 to problem.Sublevel2[s1,s2]  do
           begin
             case    s1     of
              1: begin
                 if   problem.level3[s2,s3] = normvector1[a]
                Then begin
                 specfile2.normindex[a]:=norm.specindex[S1];
                 goto telosx2 ;
               end ;
             end ;
              2: begin
                 if   problem.level4[s2,s3] = normvector1[a]
                then begin
                 specfile2.normindex[a]:=norm.specindex[S1];
                 goto telosx2 ;
                 end ;
               end ;
              3: begin
                 if problem.level5[s3] = normvector1[a] then
                 begin
                 specfile2.normindex[a]:=norm.specindex[S1];
                 goto telosx2 ;
                 end ;
               end ;
             4: begin
                if problem.level6[s2,s3] = normvector1[a]
             then begin
              specfile2.normindex[a]:= norm.specindex[S1];
                goto telosx2 ;
                end ;
              end ;
              5: begin
                if problem.level7[s2,s3]=normvector1[a] then
                begin
                specfile2.normindex[a]:=norm.specindex[S1];
                goto telosx2 ;
                end ;
              end ;
            end ;
          end ;
        end ;
      end ;
telosx2:
end ;
specfile2.numofcriteria := numofcriteria ;
specfile2.numofalternatives := problem.numofalternatives;
specfile2.alternatives := problem.alternatives ;
writespecfile ;
end ;
end ;
END ;
```

INCLUDE FILE STEP3-1

```
OVERLAY PROCEDURE EVALUATE (var array2:title;var w :integer;
                            var  vectortan :  vectors1 );

LABEL

  ert1,ert3 ;

CONST

  count = 3 ;



VAR

  a3,b3,c3,d3,h3,k3,f3,p3,l,a1,b1,
  levels1,i,count1,istogram : integer ;
  row,row1,lamda,ci,ri,cr,
  score,answer3,integer1 : real ;
  array5,vectorbase,exchange3 : vectors1 ;
  st : string [9] ;
  ch : char;
  lamda1,vector2 : array [1..50] of real ;
  exchange4 : array[1..20] of name ;
  matrix2,result,matrix3 : array [1..20,1..20] of real ;
  answer4 : name ;



PROCEDURE INFO ;
BEGIN
  window (1,13,80,23 );
  textbackground(14) ;
  textcolor( red ) ;
  gotoxy(1,6) ;
  writeln (  '"note : be as accurate as possible -- any #
          greater than 1 e.g, 2.45 ') ;
  Writeln ( ' a possible scale for inexact is : ' ) :
  writeln ( ' 3 = weakly important than ,       5 = strongly
              more importan than ') ;
  writeln (  ' 7 = very strongly more imp.than  9 =
    absolutely more imp. than');
 END ;
BEGIN (* main *)
  window ( 1,1,50,12 ) ;
  textbackground(blue);
  clrscr;
```

```
window (51,1,80,12);
textbackground ( white ) ;
clrscr ;
window (1,13,80,23 );

textbackground(14) ;
clrscr ;

window (1,24,80,25 );
textbackground(white) ;
clrscr ;
textcolor ( black ) ;
gotoxy( 2,1) ;
write ('step 3 :prioritization of evaluation criteria ') ;
gotoxy( 2,2) ;

write ( 'method : ahp ') ;
levels1 := w ;
if levels1 <> 0  then
begin
  window ( 1,1,50,12 ) ;
  textbackground(blue);
  clrscr;

  window (51,1,80,21);
  textbackground ( white ) ;
  clrscr ;

  window (1,13,80,23 );
  textbackground(14) ;
  clrscr ;

  if   w = 1 then
       vectortan[w] :=  1 ;
  if  w = 2 then
  begin
    window ( 1,1,50,12 ) ;
    textbackground(blue);
    textcolor ( white ) ;
    vectorbase :=  vectortan ;
    levels1 := w ;
    gotoxy ( 1,1) ;
    write (' pairwise comparison ') ;
    gotoxy ( 10,3 ) ;
    for  a1 := 1 to levels1 do
         write ( copy( array2[a1],1,5) , '    ' ) ;
    for a1 := 1 to levels1 do
    begin
      gotoxy (2 ,3+a1 );
      write (copy( array2[a1],1,5) ) ;
    end ;
```

```
 window (51,1,80,21);
 textbackground ( white ) ;
 textcolor( 0 ) ;
 gotoxy (1,1) ;
 write ( '   priority vector ' ) ;
 for a1 := 1 to levels1 do
 begin

   gotoxy ( 2 ,3 +a1 );
   write (copy( array2[a1],1,16) ) ;
 end ;
 for a := 1 to  levels1  do
 begin
   gotoxy(20,3 + a ) ;
   write ( chr ( 179 ) ) ;
 end ;
 for a := 1 to  levels1  do

 begin
   gotoxy(27,3 + a ) ;
   write ( chr ( 179 ) ) ;
 end ;

window (1,13,80,23 );
textbackground(14) ;
clrscr ;
textcolor( black ) ;
gotoxy( 2,2);
write ( 'is ',array2[1],' more important than  ',
         array2[2] , ' (y/n)  ? ' ) ;
Repeat
  gotoxy ( 75,2 ) ;
  clreol ;
  read ( answer ) ;
  answer := stupcase ( answer ) ;
until ( ( answer = 'y') or ( answer = 'n') ) ;
if answer = 'y' then
begin
  gotoxy(2,3) ;
  write ( 'how many times is  ',array2[1],' more
           important than     ',array2[2],'  ?  ') ;
  Gotoxy ( 2,4) ;
  write ( '( see note below ) ' ) ;
  info ;
  textcolor ( black ) ;
  repeat
    gotoxy(75,3);
    clreol ;
    read ( answer ) ;
    val ( answer,answer3,code ) ;
  until  (  ( code = 0 ) and ( answer3 > 0 ) ) ;
```

```
    vectortan[1] := ((10 / (answer3 + 1)) * answer3)/10 ;
    vectortan[2] := ( 10 / ( answer3 + 1 ) ) / 10 ;
    window ( 1,1,50,12 ) ;
    textbackground(blue);
    textcolor ( white ) ;
    gotoxy  ( 18, 4 )  ;
    write ( answer3:4:2) ;
    gotoxy(  10 ,5 );
    write ((1 / answer3):4:2 ) ;
  end
  else
  if answer = 'n' then
  begin
    gotoxy(2,3) ;
    write ( 'how many times is ',array2[2],' more
     important than ',array2[1],' ?  ') ;
    gotoxy ( 2,4) ;
    write ( '( See note below ' ) ;

    info ;
    textcolor ( black ) ;
    repeat
      gotoxy(75,3);
      clreol ;
      read ( answer ) ;
      val ( answer,answer3,code ) ;
    until code = 0 ;
    vectortan[2] := ((10 /(answer3 + 1) ) * answer3 )/10;
    vectortan[1] := ( 10 / ( answer3 +1  )) / 10 ;

    window ( 1,1,50,12 ) ;
    textbackground(blue);
    textcolor ( white ) ;
    gotoxy  ( 10,5);
    write ((1/ answer3):4:2) ;
    gotoxy(  18,4) ;
    write ( answer3:4:2 ) ;
  end ;
  window (51,1,80,21);
  textbackground ( white ) ;
  textcolor( black ) ;
  for a1 := 1 to levels1  do
  begin
    gotoxy(22,a1+3) ;
    write (  ( vectortan[a1]):5:3 ) ;
  end ;

  window (1,13,80,23 );
  textbackground(14) ;
  clrscr ;
  textcolor ( black ) ;
  for a1 := 1 to 2  do
  begin
    gotoxy ( (  ( 5 *  a1 )) , 9  ) ;
    write (copy( array2[a1],1,3) ) ;
  end ;

  for a1 := 1 to 2  do
  begin
    gotoxy ( (  ( 5 *  a1 )) , 10  ) ;
    write ( (vectortan[a1]):3:2 ) ;
  end ;
  textbackground ( green ) ;
  for a1 := 1 to 2  do
  begin
    gotoxy ( ( 5 * a1 ),8 ) ;
    write ( '    ' ) ;
  end ;
  for a1 := 1 to  2 do
  begin
    gotoxy ( (5 + ( 5 * a1 )) ,9 ) ;

    if(round(vectortan[a1] * 10 ) > 7 ) then
       istogram := 7
    else
      istogram := (  round ( vectortan[a1] * 10 ) ) ;
    for b1 := 1 to  istogram   do
    begin
      gotoxy ( ( ( 5 * a1 )) ,(9 -b1) ) ;
      write ( '    ') ;
    end ;
  end ;
  textbackground ( 14 ) ;
  textcolor ( black ) ;

  gotoxy ( 2,11 ) ;
  write ( 'hit any key to continue ' ) ;
  read ( kbd , ch ) ;
end ;

if   w > 2  then
begin
  for a3 := 1 to 5 do
      matrix2[a3,a3] := 1 ;
  window ( 1,1,50,12 ) ;
  textbackground(blue);
  textcolor ( white ) ;
  vectorbase :=  vectortan ;
  levelsi := w ;
  gotoxy ( 1,1) ;
  write (' pairwise comparison ') ;
  gotoxy ( 10,3 ) ;
```

```
for  a1 := 1 to levels1 do
     write ( copy( array2[a1],1,5) , '   ' ) ;
for a1 := 1 to levels1 do
begin
  gotoxy (2 ,3+a1 );
  write (copy( array2[a1],1,5) ) ;
end ;

window (51,1,80,21);
textbackground ( white ) ;
textcolor( 0 ) ;
gotoxy (1,1) ;
write ( '   priority vector ' ) ;
for a1 := 1 to levels1 do
begin
  gotoxy ( 2 ,3 +a1 );
  write (copy( array2[a1],1,18) ) ;
end ;
for a := 1 to  levels1  do
begin
  gotoxy(20,3 + a ) ;
  write ( chr ( 179 ) ) ;
end ;

for a := 1 to  levels1  do
begin
  gotoxy(27,3 + a ) ;
  write ( chr ( 179 ) ) ;
end ;

info ;

textcolor ( 0 ) ;
for  a := 1 to (  levels1 - 1 )  do
begin
  criteria1 := array2[a] ;
  for b := 1 to ( levels1 - a )   do
  begin
  criteria2 := array2[a+b] ;
  repeat
    gotoxy( 1,2 ) ;
    write ('is ',criteria1,'more important than ',
                  criteria2 ,'(y/n) ? ') ;
    Gotoxy ( 77,2 ) ;
    clreol ;
    read ( answer ) ;
    answer := stupcase ( answer ) ;
    clreol ;
  until  ((answer = 'y') or ( answer = 'n' ) ) ;
  if answer = 'y' then
  begin
  gotoxy ( 1,3 );
  write ( 'how many times is ',criteria1:5,' more
           important than  ', criteria2:5 ,'? ');
  gotoxy ( 1,4) ;
  write (  '  ( See note below ) ' ) ;
  repeat
    gotoxy( 77 ,3 ) ;
    clreol ;
    read ( answer ) ;
    val   ( answer , answer3 , code ) ;
  until (( code = 0 ) and ( answer3 > 0 ) ) ;
  matrix2[a,a+b] := answer3 ;
  matrix2[a+b,a] :=   ( 1 / answer3 ) ;
  matrix2[a,a]   := 1 ;

  window ( 1,1,50,12 ) ;
  textbackground(blue);
  textcolor ( white ) ;
  gotoxy  ( ( 2 +( (a +b ) * 8 )) , 3 + a )  ;
  write ( answer3:4:2) ;
  gotoxy(  2 + (a * 8 ) ,( 3 +( a + b ) ) );
  write ((1 / answer3):4:2 ) ;
end ;
if answer = 'n' then
begin
  gotoxy ( 1,3 );

  write (  '  how many times is ',criteria2,' more
         important than ', criteria1:5 ,'? ');
  gotoxy ( 1,4) ;
  write (  '  ( See note below )' ) ;
  repeat
    gotoxy( 75 ,3 ) ;
    clreol ;
    read ( answer ) ;
    val   ( answer , answer3 , code ) ;
  until (( code = 0 ) and ( answer3 > 0 ) ) ;
  matrix2[a,a+b] :=(1/ answer3) ;
  matrix2[a+b,a] :=    answer3  ;
  matrix2[a,a]   := 1 ;

  window ( 1,1,50,12 ) ;
  textbackground(blue);
  textcolor ( white ) ;
  gotoxy  ( ( 2 +( (a +b ) * 8 )) , 3 + a )  ;
  write ((1/ answer3):4:2) ;
  gotoxy(  2 + (a * 8 ) ,( 3 +( a + b ) ) );
  write ( answer3:4:2 ) ;
end ;

window (1,13,80,23 );
```

```
       textbackground(14) ;
       textcolor ( black ) ;
       gotoxy (1,2 ) ;
       clreol ;
       gotoxy (1,3 ) ;
       clreol ;
       gotoxy (1,4 ) ;
       clreol ;
     end;
   end ;

   matrix2[levels1,levels1] := 1 ;
ert1:

   matrix3 := matrix2 ;
   for  a3 := 1 to  count  do
   begin
     for b3 := 1  to levels1 do
     begin
       for c3 := 1 to levels1 do
           array5[c3] := matrix2[b3,a3] ;

       for h3 := 1 to levels1 do
       begin
         score :=  0 ;
       for k3 := 1 to levels1 do
       begin
         integer1 := array5[k3] *  matrix2[k3,h3] ;
         score := score + integer1 ;

       end ;
       result [b3,h3] := score ;
     end ;
   end ;
   matrix2 := result ;
 end ;
 result := matrix2 ;

 for p3 := 1  to levels1  do
 begin
   row := 0 ;
   for f3 := 1  to  levels1  do
       row := row + result[p3,f3] ;
   vectorbase[p3] := row ;
 end ;
 row1 := 0 ;
 for p3 := 1 to  levels1  do
     row1 := row1 + vectorbase[p3] ;
 for p3 := 1 to  levels1 do
     vectorbase[p3] := vectorbase[p3] / row1 ;
 window (51,1,80,21);
```

```
textbackground ( white ) ;
for a1 := 1 to levels1  do
begin
  gotoxy(22,a1+3) ;
  write ( vectorbase[a1]:5:3 ) ;
end ;

window ( 1,13,80,24 ) ;
textbackground(14) ;

integer1 := 0 ;
for a1:= 1 to levels1 do
begin
  score := 0 ;
  for  b1 := 1 to levels1 do
  begin
    integer1 := matrix3[a1,b1] * vectorbase[b1] ;
    score := score + integer1 ;
  end ;
  lamda1[a1] := score ;
end ;
integer1 := 0 ;
for a1 := 1 to  levels1 do
begin
  vector2[a1] := lamda1[a1] / vectorbase[a1] ;

  integer1 :=  integer1 + vector2[a1] ;
end ;

lamda := ( integer1 / levels1 ) ;
if   levels1  = 1   then
     levels1 :=2 ;

ci := ((lamda - levels1) / (levels1 - 1 )) ;
case   levels1    of
   1:   ri :=  0.00000000001  ;
   2:   Ri :=  0.00000000001  ;
   3:   Ri :=  0.58  ;
   4:   Ri :=  0.90  ;
   5:   Ri :=  1.12  ;
   6:   Ri :=  1.24  ;
   7:   Ri :=  1.32  ;
   8:   Ri :=  1.41  ;
   9:   Ri :=  1.45  ;
   10:  Ri :=  1.49  ;
   11:  Ri :=  1.51  ;
   12:  Ri :=  1.48  ;
   13:  Ri :=  1.56  ;
   14:  Ri :=  1.57  ;
   15:  Ri :=  1.59  ;
end ;
```

```
cr := ci / ri ;

window (1,13,80,23 );
textbackground(14) ;
clrscr ;
vectortan := vectorbase ;

repeat
  count1 := 0 ;
  for a := 1 to ( levels1 - 1 )  do
  begin
    if vectorbase[a] < vectorbase[a+1]  then
    begin
      exchange3[a] := vectorbase[a] ;
      vectorbase[a] := vectorbase[a+1] ;
      vectorbase[a+1] := exchange3[a] ;
      exchange4[a] := array2[a] ;
      array2[a] := array2[a+1] ;
      array2[a+1] := exchange4[a] ;
      count1 := count1 + 1 ;
    end ;
  end;
until  count1 = 0 ;

for a1 := 1 to levels1  do
begin

  gotoxy ( (  ( 5 *  a1 )) , 9  ) ;
  write (copy( array2[a1],1,3) ) ;
end ;
for a1 := 1 to levels1  do
begin
  gotoxy ( (  ( 5 *  a1 )) , 10  ) ;

  write (vectorbase[a1]:3:2) ;
end ;

textbackground ( green ) ;
for a1 := 1 to levels1  do
begin
  gotoxy ( ( 5 * a1 ),8 ) ;
  write ( '    ' ) ;
end ;

for a1 := 1 to  problem.Levels do
begin
  gotoxy ( (5 + ( 5 * a1 )) ,9 ) ;
  if   (  round ( vectortan[a1] * 10 ) ) 7 ) then
       istogram := 7
  else
      istogram := (  round ( vectortan[a1] * 10 ) ) ;
  for b1 := 1 to  istogram   do
  begin
    gotoxy ( ( ( 5 * a1 )) ,(9 -b1) ) ;
    write ( '    ') ;
  end ;
end ;

textbackground ( 14 ) ;
textcolor ( blue ) ;
gotoxy ( 36,1) ;
write ( '** lamda max              = ', lamda:4:2 ) ;
gotoxy( 36,2 );
write ( '   consistency index   = ', ci:4:2 ) ;
gotoxy(36,3);
write ( '   randomized index    = ', ri:4:2 ) ;
gotoxy (36,4) ;
write ( '   consistency ratio   = ', cr:4:2 ) ;

gotoxy (36,6) ;
write ('** there is some statistical') ;
gotoxy( 36,7) ;
write ( '   inconsistency in your evaluation.');
Gotoxy(36,8);
write ('   (study highlighted values for ') ;
gotoxy(36,9);
write ('   probable inconsistent evaluation)') ;
textcolor ( black ) ;

for p3 := 1 to levels1 do
begin
  for f3 := 1 to levels1 do
  begin
    result [p3,f3]  := 0 ;
    matrix2[p3,f3]  := 0 ;
  end
end ;

gotoxy (2,11);
textcolor ( blue ) ;
write('do you want to modify the evaluation of the
       criteria (y/n)? ') ;
Textcolor ( black);
repeat
  gotoxy( 65,11 ) ;
  clreol ;
  read ( answer ) ;
  answer := stupcase ( answer ) ;
until  ( ( answer = 'y') or ( answer = 'n' ) ) ;
window (1,13,80,23 );
textbackground(14) ;
```

```
 if answer = 'y' then
 begin
   clrscr ;
   error := false ;
   repeat
     gotoxy ( 2,2) ;
     clreol;
     write ( 'name of the first criteria   ?  ' ) ;
     Read ( answer ) ;
     answer :=  copy(answer,1,4) ;
     answer := stupcase ( answer ) ;
     for a1:=1 to levels1 do
     begin
       answer4 := copy( array2[a1],1,4) ;
       if ( answer4 = answer ) then
          error := true;
     end;
   until  error ;
   a := 0 ;
   repeat
     a := a +1 ;
     answer4 := copy( array2[a],1,4)
   until  (  answer = answer4 ) ;
   criteria1 := array2[a] ;
ert3:
   error := false ;
   repeat
     gotoxy ( 2,3) ;
     clreol ;
     write ( 'name of the second criteria  ?  ' ) ;
     Read ( answer ) ;
     answer := stupcase ( answer ) ;
     answer :=  copy(answer,1,4) ;
     for b1 := 1 to levels1 do
     begin
       answer4 := copy( array2[b1],1,4) ;
       if   ( answer4 = answer )  then
             error := true;
     end;

   until  error  ;
   answer4 := copy ( criteria1,1,4) ;
   if   (  answer = answer4 )  then
        goto ert3 ;

   b := 0 ;
   repeat
     b := b +1 ;
     answer4 := copy( array2[b],1,4)
   until   ( answer4 = answer ) ;
   criteria2 := array2[b] ;
```

```
window ( 1,1,50,12 ) ;
textbackground(blue);
matrix2 := matrix3 ;
textcolor ( red + 16 ) ;
gotoxy  ( ( 2 +( b * 8 )) , 3 + a )  ;
write ( matrix2[a,b]:4:2 ) ;

textcolor ( black ) ;
window (1,13,80,23 );
textbackground(14) ;
clrscr ;
repeat
  gotoxy( 1,2 ) ;
  write (  '  is ',criteria1 , ' more important than  ' ,
             criteria2 ,' (y/n)            ?   '  ) ;

  Gotoxy ( 75,2 ) ;
  clreol ;
  read ( answer ) ;
  answer := stupcase ( answer ) ;
  clreol ;
until  ( ( answer = 'y') or ( answer = 'n' ) ) ;
if answer = 'y' then
begin
  gotoxy ( 1,3 );
  write (   '  how many times is ',criteria1,' more
    important than ',criteria2 , ' ?  ');
  gotoxy ( 1,4) ;
  write (  '  ( See note below ' ) ;
  info ;
  repeat
    gotoxy( 75 ,3 ) ;
    clreol ;
    read ( answer ) ;
    val  ( answer , answer3 , code ) ;
  until ( (  code = 0 ) and ( answer3 > 0 ) )    ;
  matrix2[a,b] := answer3 ;
  matrix2[b,a] :=   ( 1 / answer3 ) ;
  matrix2[a,a]   := 1 ;
  window ( 1,1,50,12 ) ;
  textbackground(blue);
  textcolor ( white ) ;

  gotoxy  ( ( 2 +( b * 8 )) , 3 + a )  ;
  write ( answer3:4:2) ;
  gotoxy(  2 + (a * 8 ) ,( 3 +  b  ) );
  write ((1 / answer3):4:2 ) ;
end ;
window (1,13,80,23 );
textbackground(14) ;
textcolor ( black ) ;
```

```
   if answer = 'n' then
   begin
     gotoxy ( 1,3 );
     write ( '  how many times is ',criteria2,
              ' more important than ', criteria1 ,'? ');
     gotoxy ( 1,4);
     write ( '  ( See note below ' ) ;
     info ;
     repeat
       gotoxy(75,3 ) ;
       clreol ;
       read ( answer ) ;
       val  ( answer , answer3 , code ) ;
     until ( (  code = 0 ) and ( answer3 <> 0 ) )    ;
     matrix2[a,b] :=(1/ answer3) ;
     matrix2[b,a] :=    answer3  ;
     matrix2[a,a]   := 1 ;

     window ( 1,1,50,12 ) ;
     textbackground(blue);
     gotoxy  ( ( 2 +( b  * 8 ) ), 3 + a )  ;
     write ((1/ answer3):4:2) ;
     gotoxy(  2 + (a * 8 ) ,( 3 + b  ) );
     write ( answer3:4:2 ) ;
   end ;
   window (1,13,80,23 );
   textbackground(14) ;
   gotoxy (1,2 ) ;
   clreol ;
   gotoxy (1,3 ) ;
   clreol ;

goto ert1

    end ;
  end;

  window(1,1,80,25);
  gotoxy(1,1) ;
 end ;
END ;



OVERLAY PROCEDURE DIRECT1 (var array2:title;var w:integer ;
                           var  vectortan :  vectors1  ) ;

LABEL
  ert1,ert3 ;
```

```
CONST

  count = 3 ;

VAR

  a3,b3,c3,d3,h3,k3,f3,p3,l,a1,b1,
  levels1,i,count1,istogram : integer ;
  row,row1,lamda,ci,ri,cr,
  score,answer3,integer1 : real ;
  array5,vectorbase,exchange3 : vectors1 ;
  st : string [9] ;
  ch : char;
  lamda1,vector2 : array [1..50] of real ;
  exchange4 : array[1..20] of name ;
  matrix2,result,matrix3 : array [1..20,1..20] of real ;
  answer4 : name ;


PROCEDURE INFO ;
BEGIN

   window (1,13,80,23 );
   textbackground(14) ;
   clrscr ;
   textcolor( red ) ;
   gotoxy(1,10) ;
   writeln ( '"note : be as accurate as possible
             -- any # between 0 and 10 e.g, 2.45 ') ;
   Writeln ( ' a possible scale for inexact is : ' ) ;
   writeln (  ' 3 = weakly important than ,5 = strongly more
             importan than ') ;
   writeln ( ' 7 = very strongly more imp.than
              9 = absolutely more imp. than');

END ;


BEGIN (* main *)

  window ( 1,1,50,12 ) ;
  textbackground(blue);
  clrscr;

  window (51,1,80,12);
  textbackground ( white ) ;

  clrscr ;
  window (1,13,80,23 );
  textbackground(14) ;
  clrscr ;
```

```
window (1,24,80,25 );
textbackground(white) ;
clrscr ;
textcolor ( black ) ;
gotoxy( 2,1) ;
write ( 'step 3 : prioritization of evaluation criteria');
gotoxy( 2,2) ;
write ( 'direct input of criteria weights ') ;
levels1 := w ;
if levels1 <> 0  then
begin
  window ( 1,1,50,12 ) ;
  textbackground(blue);
  clrscr;

  window (51,1,80,21);
  textbackground ( white ) ;
  clrscr ;

  window (1,13,80,23 );
  textbackground(14) ;
  clrscr ;

  if   w = 1 then
       vectortan[w] :=  1
  else
  begin
    for a3 := 1 to 5 do
        matrix2[a3,a3] := 1 ;
    window ( 1,1,50,12 ) ;
    textbackground(blue);
    textcolor ( white ) ;

    vectorbase :=  vectortan ;
    levels1 := w ;
    gotoxy ( 1,1) ;
    window (51,1,80,21);
    textbackground ( white ) ;
    textcolor( 0 ) ;
    gotoxy (1,1) ;
    write ( '   priority vector ' ) ;
    for a1 := 1 to levels1 do
    begin
      gotoxy ( 2 ,3 +a1 );
      write (copy( array2[a1],1,18) ) ;
    end ;
    for a := 1 to  levels1  do
    begin
      gotoxy(20,3 + a ) ;
      write ( chr ( 179 ) ) ;
    end ;
```

```
      for a := 1 to  levels1  do
      begin
        gotoxy(27,3 + a ) ;
        write ( chr ( 179 ) ) ;
      end ;

ert1:
      info ;
      textcolor ( 0 ) ;
      gotoxy ( 2,2) ;
      write ( 'enter the weights of the criteria : ' ) ;
      for  a := 1 to levels1  do
      begin
        gotoxy ( 2 , 2+a ) ;
        write  ( array2[a] , ' : ') ;
      end;

      for  a := 1 to levels1  do
      begin
        repeat
          gotoxy ( length(array2[a])+5 , 2+a ) ;
          clreol ;
          read ( answer ) ;
          val  ( answer , answer3 , code ) ;
        until (( code = 0 ) and ( answer3 > -1 ) and
                (answer3 < 11) ) ;
        vectorbase[a] := answer3 ;
      end ;

      row1 := 0 ;
      for p3 := 1 to  levels1  do
          row1 := row1 + vectorbase[p3] ;
      for p3 := 1 to  levels1 do
          vectorbase[p3] := vectorbase[p3] / row1 ;

      window (51,1,80,21);
      textbackground ( white ) ;
      for a1 := 1 to levels1  do
      begin
        gotoxy(22,a1+3) ;
        write ( vectorbase[a1]:5:3 ) ;
      end ;

      window (1,13,80,23 );
      textbackground(14) ;
      clrscr ;
      vectortan := vectorbase ;
      repeat
      count1 := 0 ;

      for a := 1 to ( levels1 - 1 )  do
```

```
    begin
      if vectorbase[a] < vectorbase[a+1]  then
      begin
        exchange3[a] := vectorbase[a] ;
        vectorbase[a] := vectorbase[a+1] ;
        vectorbase[a+1] := exchange3[a] ;
        exchange4[a] := array2[a] ;
        array2[a] := array2[a+1] ;
        array2[a+1] := exchange4[a] ;
        count1 := count1 + 1 ;
      end ;
    end;
  until  count1 = 0 ;

  for a1 := 1 to levels1  do
  begin
    gotoxy ( (   ( 5 *  a1 )) , 9   ) ;
    write (copy( array2[a1],1,3) ) ;
  end ;

  for a1  := 1 to levels1  do
  begin
    gotoxy ( (   ( 5 *  a1 )) , 10   ) ;
    write (vectorbase[a1]:3:2) ;
  end ;

  textbackground ( green ) ;
  for a1  := 1 to levels1  do
  begin
    gotoxy ( ( 5 * a1 ),8 ) ;
    write ( '    ' ) ;
  end ;

  for a1 := 1 to  levels1 do
  begin
    gotoxy ( (5 + ( 5 * a1 )) ,9 ) ;
    for b1 := 1 to   round ( vectorbase[a1] * 10 )    do
    begin
      gotoxy ( ( ( 5 * a1 )) ,(9 -b1) ) ;
      write ( '    ') ;
    end ;
  end ;

  gotoxy (2,11);
  textbackground ( 14 ) ;
  textcolor ( blue ) ;
  write(' do you want to modify the evaluation of
          the criteria (y/n) ? ') ;
  Textcolor ( black);
  repeat
    gotoxy( 65,11 ) ;
```

```
      clreol ;
      read ( answer ) ;
      answer := stupcase ( answer ) ;
    until  ((answer = 'y') or ( answer = 'n')) ;
    window (1,13,80,23 );
    textbackground(14) ;
    if answer = 'y' then
    begin
      clrscr ;
      goto ert1 ;
    end ;
  end ;
end ;
END ;
```

INCLUSE FILE STEP3-2

```
PROCEDURE SELECTCRITERIA (var  problem : case1 ;
                          var  vector1 : vectors1 ;
                          var   vector2,vector3,
                               vector4,vector5,
                               vector6,vector7 :vectors ;
                          var  normvector1 : vectorg ;
                          var  normvector2 : vectorn ;
                          var  numofcriteria : integer  ) ;


VAR

f,a,b,c          : integer ;
normvector5      : vectorg ;
normvector6      : vectorn ;
numofcriteria1   : integer ;


BEGIN

  for a := 1 to 125 do
  begin
    normvector2[a] := 0 ;
    normvector1[a] := ' ' ;
  end ;
  f := numofcriteria ;
  for a := 1 to problem.Levels do
  begin
    if  problem.Sublevel1[a] = 0 then
    begin
      normvector1[f] := problem.Level1[a] ;
      normvector2[f] := vector1[a];
```

```
          f := f + 1 ;
        end
        else
        begin
          for b:= 1 to problem.Sublevel1[a] do
          begin
            if problem.Sublevel2[a,b] = 0 then
            begin
              normvector1[f] := problem.Level2[a,b] ;
              normvector2[f] := vector2[a,b] ;
              f := f + 1 ;
            end
            else
            begin
              for c := 1 to problem.Sublevel2[a,b] do
              begin
                case    a    of
                    1: begin
                       normvector1[f] := problem.Level3[b,c] ;
                       normvector2[f] := vector3[b,c] ;
                       f := f + 1 ;
                       end ;
                    2: begin
                       normvector1[f] := problem.Level4[b,c] ;
                       normvector2[f] := vector4[b,c] ;
                       f := f + 1 ;
                       end ;
                    3: begin
                       normvector1[f] := problem.Level5[b,c] ;
                       normvector2[f] := vector5[b,c] ;
                       f := f + 1 ;
                       end ;
                    4: begin
                       normvector1[f] := problem.Level6[b,c] ;
                       normvector2[f] := vector6[b,c] ;
                       f := f + 1 ;
                       end ;
                    5: begin
                       normvector1[f] := problem.Level7[b,c] ;
                       normvector2[f] := vector7[b,c] ;
                       f := f + 1 ;
                       end ;
                end;
              end;
            end;
          end;
       end;
    end;
    numofcriteria := f ;

    END ;
```

```
PROCEDURE FINALCRITERIA  ( var normvector1   : vectorg ;
                           var normvector2   : vectorn ;
                           var numofcriteria : integer   ) ;

VAR

  a,b,number,startpoint : integer ;
  sum,precent : real ;
  answer : char ;
  numofcriteria1 : integer ;
  normvector5 : vectorg ;
  normvector6 : vectorn ;


PROCEDURE WRITECRITERIA ;

VAR

  linex,rowx : integer ;
BEGIN
  window ( 1,1,80,15) ;
  textbackground ( blue ) ;
  textcolor ( white ) ;
  clrscr ;
  gotoxy ( 3,2) ;
  write ( 'the final criteria ( ', numofcriteria ,')
           and their weights are  :  '  ) ;
  gotoxy ( 1,4 ) ;
  sum := 0 ;
  numofcriteria1 := numofcriteria ;
  normvector5    := normvector1 ;
  normvector6    := normvector2 ;
  for a := 1 to  numofcriteria  do
     sum := sum + normvector2[a] ;
  for a := 1 to  numofcriteria do
  begin
    normvector2[a] := normvector2[a] / sum ;
  end ;
  linex := 3 ; rowx := 2 ;
  for a := 1 to numofcriteria do
  begin
    if  ( linex > 13 ) then
    begin
      linex := 3 ;
      rowx := 45 ;
    end ;
    gotoxy ( rowx,linex ) ;
    write (a,'. ,Normvector1[a], normvector2[a]:4:2 ) ;
    linex := linex + 1 ;
  end ;
END ;
```

```
BEGIN (* main *)
  window ( 1,1,80,15) ;
  textbackground ( blue ) ;
  clrscr ;

  window ( 1,16,80,23) ;
  textbackground ( 14   ) ;
  clrscr ;

  window ( 1,24,80,25 ) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy ( 2,1 ) ;
  write ('step 3 :prioritization of evaluation criteria ') ;
  gotoxy (2,2) ;
  write ( 'determine the number of the criteria ' ) ;

  startpoint := numofcriteria ;
  writecriteria ;

  window ( 1,16,80,23) ;
  textbackground ( 14 ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy ( 2,2) ;
  write ('do you want to reduce the number of the
          criteria (y/n)?  ' ) ;
  Repeat
    gotoxy (63,2) ;
    clreol ;
    read ( answer ) ;
    answer := stupcase ( answer ) ;
  until  ( ( answer ='y') or ( answer = 'n') ) ;

  repeat
    if answer = 'y' then
    begin
      gotoxy( 2,2) ;
      clreol ;
      write ( 'you have two methods : ' ) ;
      gotoxy ( 4,4);
      write ( '  1. Define the number of the
                    criteria that you want to use ');
      gotoxy ( 4,5) ;
      write ( '  2. Define the sum ( % ) that you wish ' ) ;
      gotoxy ( 2,7 ) ;
      write  ('method that you wish (1 or 2) ? '  ) ;
      Repeat
        gotoxy( 50,7);
        clreol ;
        read ( answer ) ;
      until ( ( answer = '1') or ( answer = '2' ) ) ;
      if answer = '1' then
      begin
        gotoxy ( 2,2) ;
        write ('the number of the criteria that you wish
                (up to',startpoint , ' ) ?  ' ) ;
        Repeat
          gotoxy ( 60 ,2 ) ;
          clreol ;
          read ( number ) ;
        until ( number <= startpoint  ) ;
        numofcriteria := number ;
      end ;
      if answer = '2' then
      begin
        clrscr ;
        gotoxy ( 2,2 ) ;
        write (  'enter the value (%) that you wish : ' ) ;
        read ( precent ) ;
        sum := 0 ;
        a := 0 ;
        repeat
          a := a + 1 ;
          sum := sum + ( normvector2[a] * 100 ) ;
          b := a ;
        until (  sum > precent )     ;
        numofcriteria := ( b - 1)      ;
      end ;
    end ;
    writecriteria ;
    window ( 1,16,80,23) ;
    clrscr ;
    textcolor ( black ) ;
    gotoxy ( 2,2 ) ;
    write ('do you want to change the number of the
            criteria (y/n) ? ' ) ;
    Repeat
      gotoxy (70,2 ) ;
      read ( answer ) ;
      answer := stupcase ( answer ) ;
    until (( answer ='y') or ( answer = 'n') ) ;
    if answer = 'y' then
    begin
      numofcriteria := numofcriteria1 ;
      normvector1    := normvector5 ;
      normvector2    := normvector6 ;
      clrscr ;
    end ;
  until ( answer = 'n') ;
END ;
```

INCLUDE FILE STEP4

```
PROCEDURE SOLVEWITHAHP ;

LABEL

  telos3x ;

PROCEDURE DISPLAYFINALS ;
BEGIN

  window (1,1,80,23) ;
  textbackground ( blue   ) ;
  clrscr ;

  window (1,24,80,25) ;
  textbackground ( white   ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy ( 2,1) ;

  if index then
     write ( 'step 5 : direct input of the weights' )
  else
     write ( 'step 4 : individual evaluation of
alternatives');

  gotoxy ( 2,2) ;
  write ( 'final result' ) ;

  window (1,1,80,23) ;
  textbackground ( blue   ) ;
  clrscr ;
  textcolor ( white    ) ;

  gotoxy ( 2,3 ) ;
  write ( ' final solution ' ) ;

  for a1 := 1 to problem.Numofalternatives  do
  begin
    textcolor ( white ) ;
    gotoxy ( (  ( 5 *  a1 )) , 19  ) ;
    write ( copy( problem.Alternatives[a1],1,3) ) ;
    gotoxy ( (  ( 5 *  a1 )) , 20  ) ;
    textcolor ( red ) ;
    write ( altvector1[a1]:3:2 ) ;
  end ;

  textbackground ( red ) ;
  for a1 := 1 to  problem.Numofalternatives do
  begin
    gotoxy ( (5 + ( 5 * a1 )) ,17 ) ;

    end;
    until  count = 0 ;
END ;

BEGIN (* main *)

  if index then
  begin
    alternatives1 := problem.alternatives ;

    Evaluate3 ( alternatives1 , altvector  ,
                problem.Numofalternatives ,normvector1,ax) ;

    alternativesx := problem.alternatives ;
    altvectorx     := altvector ;
    altvector1    := altvector ;
   End
   else
   begin
     if norm.Specialized  then
        altmatrix := specfile2.Altmatrix ;
     if index2  then
     begin
       for ax := 1 to numofcriteria  do
       begin
         if norm.specialized  Then
         begin
           if specfile2.normindex[ax] <> namex  Then
              goto telos3x ;
         end ;
         alternatives1 := problem.Alternatives ;
         evaluate1 ( alternatives1 , altvector  ,
                     problem.Numofalternatives ,
         normvector1,ax);
         for b := 1 to problem.Numofalternatives  do
             altmatrix [ b,ax ]   := altvector[b] ;
telos3x:
      end ;
      if norm.Specialized then
      begin
       specfile2.Electre.Numoftries :=
                         solution.Electre.Numoftries ;
       specfile2.Electre.Status := solution.Electre.Status;
       specfile2.Ahp.Status := solution.Ahp.Status ;
       specfile2.Ahp.Numoftries:=  solution.Ahp.Numoftries;

       specfile2.Altmatrix := altmatrix   ;
       writespecfile ;
```

```
          end ;
       end
       else

       begin
          alternatives1 := problem.Alternatives ;
          direct2a ( alternatives1 , altvector  ,
                      problem.Numofalternatives,normvector1,ax) ;
          if norm.Specialized then
          begin
            specfile2.Electre.Numoftries :=
                                solution.Electre.Numoftries ;


            specfile2.Altmatrix := altmatrix    ;

          end ;
       end ;

       if not norm.Specialized then
          sortresult
       else
       begin
          b := 0 ;
          for a := 1 to 3 do
          begin
            if specfile2.Finalindex[a]  then
               b := b + 1 ;
          end ;
          if b = norm.Numofusers then
          begin
            sortresult ;
            specfile2.Completedall := true ;
          end ;
       end ;
    end  ;

    if not norm.Specialized then
       displayfinals
    else
    begin
       if specfile2.Completedall then
       begin
          displayfinals ;
          specfile2.Ahp.Status := true ;
          specfile2.Numofcriteria := numofcriteria ;
          specfile2.Normvector2 := normvector2 ;
          specfile2.Normvector1 := normvector1  ;
          specfile2.Numofalternatives  :=
problem.Numofalternatives ;
```

```
      writespecfile ;
      answer   := concat ( '.',Inte ) ;
      problname   := concat ( problname ,answer ) ;
    end ;
 end ;
END ;
```

PROCEDURE COMPUTEALTERNATIVES ;

```
LABEL

  telos6 ;

PROCEDURES ALLUSERS ;

LABEL

  telos6x ;

BEGIN

  if  methodx = 'electre'  then
  begin
    countimes := solution.Electre.Numoftries ;
    if norm.Modify then
    begin
      if countimes < norm.Modifytimes  then
      begin
        countimes := countimes  + 1 ;
        clrscr    ;
        solution.Electre.Status := true ;
        solution.Electre.Numoftries := countimes ;
        electre   ;
      end
      else
      begin
        clrscr ;
        gotoxy ( 5,9) ;
        write ( 'you cant modify your output ' ) ;
        gotoxy ( 5,10 );
        write ( 'hit any key to continue ') ;
        read ( kbd,ch ) ;
        goto telos6x ;
      end;
    end
    else
    begin

      if countimes  = 0   then
      begin
        countimes := countimes  + 1  ;
      clrscr   ;
      solution.Electre.Status := true ;
      solution.Electre.Numoftries := countimes ;
      electre  ;
    end
    else
    begin
      clrscr ;
      gotoxy ( 5,9) ;

      write ( 'you cant modify your output ' ) ;
      gotoxy ( 5,10 );
      write ( 'hit any key to continue ') ;
      read ( kbd,ch ) ;
      goto telos6x ;
    end;
  end;
end
else
begin
  countimes := solution.Ahp.Numoftries ;
  if norm.Modify then
  begin
    if countimes < norm.Modifytimes  then
    begin
      countimes := countimes  + 1   ;
      index := false ;
      if methodx = 'ahp' then
         index2 := true
      else
        index2 := false ;
        solvewithahp ;
      end
      else
      begin
        clrscr ;
        gotoxy ( 5,9) ;
        write ( 'you cant modify your output ' ) ;
        gotoxy.( 5,10 );
        write ( 'hit any key to continue ') ;
        read ( kbd,ch ) ;
        goto telos6x ;
      end;
    end
    else
    begin
      if countimes  = 0   then
      begin
        countimes := countimes  + 1 ;
        index := false ;
        if methodx = 'ahp' then
```

```
             index2 := true
          else
            index2 := false ;
          solvewithahp ;
          clrscr   ;
        end
        else
        begin
          clrscr ;
          gotoxy ( 5,9) ;
          write ( 'you cant modify your output ' ) ;

          gotoxy ( 5,10 );
          write ( 'hit any key to continue ') ;
          read ( kbd,ch ) ;
          goto telos6x ;
        end;
      end ;
    end;
telos6x:
END ;


BEGIN (* main *)

  string128 :=  'step 4 : individual evaluation of
     alternatives';
  diskstatus ;
  clrscr ;
  window ( 1,24,80,25) ;
  textcolor ( black ) ;
  textbackground ( white ) ;
  gotoxy ( 2,2) ;
  clreol ;
  write ( ' identification of the problem
            methods :  ahp,electre,direct') ;
  window ( 1,13,80,23) ;
  textbackground ( 14 );
  clrscr ;
  read1 ;
  readproblemfile ;
  read2 ;
  readnormfile ;
  read3 ;
  if not norm.Specialized then
  begin
    if ( not exist(pruser) ) then
    begin
      clrscr ;
      write ( ' you must compute first the criteria ' ) ;
      wait ;
      goto telos6 ;
    end ;
  end

  else
  begin
    readspecfile ;
    if ( not specfile2.Completed ) then
    begin
      clrscr ;
      write ( ' the evaluation of the criteria is
                not yet completed ' ) ;
      wait ;
      goto telos6 ;

    end ;
  end ;

  if ( not norm.Specialized ) then
  begin
    readsolutionfile ;
    numofcriteria := solution.Numofcriteria ;
    normvector1   := solution.Normvector1   ;
    normvector2   := solution.Normvector2   ;
  end
  else
  begin
    numofcriteria := specfile2.Numofcriteria ;
    normvector1   := specfile2.Normvector1   ;
    normvector2   := specfile2.Normvector2   ;
  end ;

  read4 ;
  read5 ;
  writenormfile ;
  if  ( norm.Specialized ) then
  begin
   solution.Electre.Numoftries         :=
specfile2.Electre.Numoftries;
   solution.Electre.Status := specfile2.Electre.Status ;
   solution.Ahp.Status := specfile2.Electre.Status ;
   solution.Ahp.Numoftries := specfile2.Electre.Numoftries ;
   a := 0 ;
   repeat
     a := a + 1 ;
   until ( namex = norm.Usersnames[a] ) ;
   specfile2.Finalindex[a] := true ;
  end ;
  allusers ;

 telos6: ;
END ;
```

INCLUDE FILE STEP4-1

```
OVERLAY PROCEDURE EVALUATE1 (VAR ALTERNATIVES : TITLE1 ;
                             VAR  ALTVECTOR3 : VECTORF ;
                             VAR  W : INTEGER ;
                             VAR  NORMVECTOR1 : VECTORG ;
                             VAR  AX : INTEGER );
LABEL
   ert,ert4 ;

CONST
   count = 3 ;

VAR

   matrix2,result,matrix3 : array [1..20,1..20] Of real ;
   array5,altvector5,exchange3,altvector6 : vectorf ;
   lamda1,vector2 : vectorf ;
   exchange4,alternativesk : title1  ;
   numofalternatives,I,count1,x1,y1,a1,b1,
   a3,b3,c3,d3,h3,k3,f3,p3,l : integer ;
   score,answer3,integer1,row,row1,
   lamda,ci,ri,cr : real ;
   st : string [9] ;
   ch : char;


PROCEDURE INFO1
begin
  window (1,y1+1,80,23);
  textbackground (14) ;
  textcolor( red ) ;
  gotoxy(1,5) ;
  writeln ( '"note : be as accurate as possible
            -- any # greater than 1 ') ;
  writeln ( '         e.g ,2.45 or 15.3    ' ) ;
  Writeln ( ' a possible scale for inexact is : ' ) ;
  writeln ( ' 3 = weakly important than , 5 = strongly more
            importan than ') ;
  writeln ( ' 7 = very strongly more imp.than
            9 = absolutely more imp. than');
  Textcolor ( black ) ;
end ;

BEGIN

  numofalternatives := w ;
  case numofalternatives of
     1,2,3,4,5,6,7 : begin
                       x1 := 50 ; y1 :=12 ;
```

```
                   end ;
   8,9,10,11     : begin

                     x1 := 55 ; y1 :=13 ;
                   end ;
   12,13,14,15   : begin
                     x1 := 70 ; y1 :=15 ;
                   end ;
end ;

numofalternatives := w ;
if numofalternatives <> 0  then
begin

  window (1,1,x1,y1);
  textbackground(blue);
  clrscr;

  window (x1+1,1,80.y1);
  textbackground(white) ;
  clrscr ;

  window (1,y1+1,80,23);
  textbackground(14) ;
  clrscr ;

  window ( 1,24,80,25) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy (2,1) ;
  write ('step 4:individual evaluation of alternatives ');
  gotoxy ( 2,2 ) ;
  write (  'evaluation of alternatives according to
   criterion ',normvector1[ax],' methodx' ) ;
  window (1,1,x1,y1);
  textbackground ( blue ) ;
  textcolor ( white ) ;
  altvector5 :=  altvector3 ;
  numofalternatives := w ;
  gotoxy ( 1,1) ;
  write (' pairwise comparison ') ;
  gotoxy ( 10,3 ) ;

  for  a1 := 1 to numofalternatives do
         write ( copy( alternatives[a1],1,5):5 , '    ' ) ;
  for a1 := 1 to numofalternatives do
  begin
    gotoxy (2 ,3+a1 );
    write (copy( alternatives[a1],1,5):5 ) ;
  end ;
```

```
window (x1+1,1,80,y1);
textbackground ( white ) ;
textcolor( 0 ) ;
gotoxy (1,1) ;
write ( '   priority vector ' ) ;

for a1 := 1 to numofalternatives do
begin
  gotoxy ( 2 ,3 +a1 );
  write (copy( alternatives[a1],1,18) ) ;
end ;
for a := 1 to  numofalternatives  do
begin
  gotoxy(20,3 + a ) ;
  write ( chr ( 179 ) ) ;

end ;
for a := 1 to  numofalternatives  do
begin
  gotoxy(27,3 + a ) ;
  write ( chr ( 179 ) ) ;
end ;

window (1,y1+1,80,23);
textbackground(14) ;
clrscr ;

info1 ;
for a := 1 to numofalternatives do
    matrix2[a,a] := 1 ;

for  a := 1 to (  numofalternatives - 1 )  do
begin
  criteria1 := alternatives[a] ;
  for b := 1 to ( numofalternatives - a )   do
  begin
     criteria2 := alternatives[a+b] ;
     repeat
       textcolor ( 0 ) ;
       gotoxy( 1,2 ) ;
       write (   '  is ',criteria1 , ' better than  ' ,
            criteria2 ,' (y/n)             ?   '  ) ;
       Gotoxy ( 64,2 ) ;
       clreol ;
       read ( answer ) ;
       answer := stupcase ( answer ) ;
       clreol ;
    until  ( ( answer = 'y') or ( answer = 'n' ) ) ;
    if answer = 'y' then
    begin
      textcolor ( black ) ;
  gotoxy ( 1,3 );
  write (  '  how many times is ',criteria1,' better
           than  ', criteria2 , '  ?  ');
  Gotoxy (1,4) ;
  write (  '  ( see note below ) ' ) ;

  repeat
    gotoxy( 64 ,3 ) ;
    clreol ;

    read ( answer ) ;
    answer := stupcase ( answer ) ;
    val  ( answer , answer3 , code ) ;
  until ( (  code = 0 ) and ( answer3 > 0 ) )    ;

  matrix2[a,a+b] := answer3 ;
  matrix2[a+b,a] :=   ( 1 / answer3 ) ;
  matrix2[a,a]   := 1 ;

  window (1,1,x1,y1);
  textbackground ( blue ) ;
  gotoxy  ( ( 2 +( (a +b ) * 8 )) , 3 + a )  ;
  textcolor ( white ) ;
  write ( answer3:4:2) ;
  gotoxy(  2 + (a * 8 ) ,( 3 +( a + b ) ) );
  write ((1 / answer3):4:2 ) ;
end ;

window ( 1,y1+1,80,23) ;
textbackground ( 14 ) ;
textcolor ( black ) ;
if answer = 'n' then
begin
  gotoxy ( 1,3 );
  write ( '  how many times is ',criteria2,'
          better than  ', criteria1 , '  ?  ');
  Gotoxy ( 1,4) ;
  write ( '  ( see note below ) ' ) ;
  repeat
    gotoxy(64,3 ) ;
    clreol ;
    read ( answer ) ;
    val  ( answer , answer3 , code ) ;
  until ( (  code = 0 ) and ( answer3 <> 0 ) )    ;
  matrix2[a,a+b] :=(1/ answer3) ;
  matrix2[a+b,a] :=    answer3  ;
  matrix2[a,a]   := 1 ;

  window ( 1,1,x1,y1) ;
  textbackground ( blue ) ;
  textcolor ( white ) ;
```

```
       gotoxy  ( ( 2 +( (a +b ) * 8 )) , 3 + a )  ;
       write ((1/ answer3):4:2) ;
       gotoxy(  2 + (a * 8 ) ,( 3 +( a + b ) ) );
       write ( answer3:4:2 ) ;
     end ;

     window ( 1,y1+1,80,23) ;
     textbackground ( 14 ) ;
     gotoxy (1,2 ) ;
     clreol ;
     gotoxy (1,3 ) ;
     clreol ;

     gotoxy (1,4) ;
     clreol ;
   end;
 end ;

 matrix2[numofalternatives,numofalternatives] := 1 ;

 ert:

 (*   matrix multiplication  *)

 matrix3 := matrix2 ;
 for  a3 := 1 to  count  do
 begin
   for b3 := 1  to numofalternatives do
   begin
     for c3 := 1 to numofalternatives do
         array5[c3] := matrix2[b3,a3] ;
     for h3 := 1 to numofalternatives do
     begin
       score :=  0 ;
       for k3 := 1 to numofalternatives do
       begin
         integer1 := array5[k3] *  matrix2[k3,h3] ;
         score := score + integer1 ;
       end ;
       result [b3,h3] := score ;
     end ;
   end ;
   matrix2 := result ;
 end ;

 result := matrix2 ;

(*  normalise vector   *)


for p3 := 1  to numofalternatives  do
```

```
begin
  row := 0 ;
  for f3 := 1  to  numofalternatives  do
         row := row + result[p3, f3] ;
  altvector5[p3] := row ;
end ;

row1  := 0 ;
for p3 := 1 to  numofalternatives  do
    row1 := row1 + altvector5[p3] ;
for p3 := 1 to  numofalternatives do
begin
  altvector5[p3] := altvector5[p3] / row1 ;
end ;
window ( x1 + 1 ,1,80,y1);

textbackground ( white  ) ;
textcolor ( black ) ;
for a1 := 1 to numofalternatives  do
begin
  gotoxy(22,a1+3) ;
  write ( altvector5[a1]:5:3 ) ;
end ;
window ( 1,y1+1,80,23) ;

textbackground ( 14 ) ;
clrscr ;

(* comput lmax and the other data *)

integer1 := 0 ;
for a1:= 1 to numofalternatives do
begin
  score := 0 ;
  for  b1 := 1 to numofalternatives do
  begin
    integer1 := matrix3[a1,b1] * altvector5[b1] ;
    score := score + integer1 ;
  end ;
  lamda1[a1] := score ;
end ;

integer1 := 0 ;
for a1 := 1 to  numofalternatives do
begin
  vector2[a1] := lamda1[a1] / altvector5[a1] ;
  integer1 :=  integer1 + vector2[a1] ;
end ;
lamda := ( integer1 / numofalternatives ) ;
if   numofalternatives  = 1   then
     numofalternatives :=2 ;
```

```
ci:=((lamda-numofalternatives)/(numofalternatives - 1));
case   numofalternatives    of

   1:   ri :=  0.000001  ;
   2:   Ri :=  0.000001  ;
   3:   Ri :=  0.58  ;
   4:   Ri :=  0.90  ;
   5:   Ri :=  1.12  ;
   6:   Ri :=  1.24  ;
   7:   Ri :=  1.32  ;
   8:   Ri :=  1.41  ;
   9:   Ri :=  1.45  ;
   10:  Ri :=  1.49  ;
   11:  Ri :=  1.51  ;
   12:  Ri :=  1.48  ;
   13:  Ri :=  1.56  ;
   14:  Ri :=  1.57  ;
   15:  Ri :=  1.59  ;
 End ;

cr := ci / ri ;
window ( 1,y1+1,80,23) ;
altvector6 := altvector5 ;
alternativesk := alternatives ;
repeat
  count1 := 0 ;
  for a := 1 to ( numofalternatives - 1 )  do

  begin
    if altvector5[a] < altvector5[a+1]  then
    begin
      exchange3[a]          := altvector5[a] ;
      altvector5[a]         := altvector5[a+1] ;
      altvector5[a+1]       := exchange3[a] ;
      exchange4[a]          := alternatives[a] ;
      alternatives[a]       := alternatives[a+1] ;
      alternatives[a+1]     := exchange4[a] ;
      count1 := count1 + 1 ;
    end ;
  end;
until  count1 = 0 ;

for a1 := 1 to numofalternatives  do
begin
  gotoxy ( (  ( 5 *  a1 )) , 10  ) ;
  write ( copy( alternatives[a1],1,3)  ) ;
end ;

for a1 := 1 to numofalternatives  do
begin
  gotoxy ( (  ( 5 *  a1 )) , 11  ) ;
```

```
    write ( altvector5[a1]:3:2  ) ;
  end ;

  textbackground ( green  ) ;
  for a1 := 1 to  numofalternatives   do
  begin
    gotoxy ( (5 + ( 5 * a1 )) ,9 ) ;
    for b1 := 1 to  round  (  altvector5[a1] * 10 )   do
    begin
      gotoxy ( ( ( 5 * a1 )) ,(9 -b1) ) ;
      write ( '   ') ;
    end ;
  end ;

  textbackground ( 14 ) ;
  textcolor ( blue ) ;
  gotoxy ( 36,1) ;
  write ( '** lamda max          = ', lamda:4:2 ) ;
  gotoxy( 36,2 );
  write ( '   consistency index  = ', ci:4:2 ) ;
  gotoxy(36,3);
  write ( '   randomized index   = ', ri:4:2 ) ;
  gotoxy (36,4) ;

  write ( '   consistency ratio  = ', cr:4:2 ) ;
  gotoxy (36,6) ;
  write ('** there is some statistical') ;
  gotoxy( 36,7) ;
  write ( '   inconsistency in your evaluation.');
  Gotoxy(36,8);

  write ('    (study highlighted values for ') ;
  gotoxy(36,9);
  write ('   probable inconsistent evaluation)') ;
  textcolor ( black ) ;

  altvector3 :=  altvector6 ;
  alternatives := alternativesk ;
  for p3 := 1 to numofalternatives do
  begin
    for f3 := 1 to numofalternatives do
    begin
      result [p3,f3]   := 0 ;
      matrix2[p3,f3]   := 0 ;
    end
  end ;
end ;

gotoxy ( 36,11 ) ;
write ( 'do you want to modify the data (y/n) ? ' ) ;
Repeat
```

```
   gotoxy( 75,11 ) ;
   clreol ;
   read ( answer ) ;
   answer := stupcase ( answer ) ;
 until  ( ( answer = 'y') or ( answer = 'n' ) ) ;

 textbackground ( 14 ) ;
 if answer = 'y' then
 begin
   clrscr ;
   error := false ;
   repeat
     gotoxy ( 2,2) ;
     clreol;
     write ( 'name of the first alternative  ? ' ) ;
     Read ( answer ) ;
     answer := stupcase ( answer ) ;
     for a1:=1 to numofalternatives do
     begin
       if answer = alternatives[a1] then
           error := true;
     end;
   until  error ;
   a := 0 ;
   repeat
     a := a +1 ;
   until answer = alternatives[a] ;

   criteria1 := answer ;
ert4:
   error := false ;
   repeat
     gotoxy ( 2,3) ;

     clreol ;
     write ( 'name of the second alternative ? ' ) ;
     Read ( answer ) ;
     answer := stupcase ( answer ) ;
     for b1 := 1 to numofalternatives do
     begin
       if answer = alternatives[b1] then
             error := true;
     end;
   until  error  ;
   if answer = criteria1 then
      goto ert4 ;
   b := 0 ;
   repeat
     b := b + 1 ;
   until answer = alternatives[b] ;
```

```
criteria2 := answer ;
window (1,1,x1,y1) ;
textbackground ( blue ) ;
matrix2 := matrix3 ;
textcolor ( red + 16 ) ;
gotoxy  ( ( 2 +( b * 8 )) , 3 + a )  ;
write ( matrix2[a,b]:4:2 ) ;
textcolor ( black ) ;

window ( 1 , y1+1 , 80,23) ;
textbackground ( 14 ) ;
clrscr ;
repeat
  gotoxy( 1,2 ) ;
  write (  'is ',criteria1 , ' better than  ' ,
criteria2,'? ');
  Gotoxy ( 64,2 ) ;
  clreol ;
  read ( answer ) ;
  answer := stupcase ( answer ) ;
  clreol ;
until  ( ( answer = 'y') or ( answer = 'n' ) ) ;
if answer = 'y' then
begin
  gotoxy ( 1,3 );
  write ('how many times is ',criteria1,' better than  ',
          criteria2 , '  ?   ');
  Gotoxy ( 1,4) ;
  write (  '  ( see note below ) ' ) ;
  info1 ;
  repeat

    gotoxy( 64 ,3 ) ;
    clreol ;
    read ( answer ) ;
    val  ( answer , answer3 , code ) ;

  until ( (  code = 0 ) and ( answer3 <> 0 ) )   ;
  matrix2[a,b] := answer3 ;
  matrix2[b,a] :=   ( 1 / answer3 ) ;
  matrix2[a,a]   := 1 ;

  window (1,1,x1,y1);
  textbackground ( blue ) ;
  gotoxy   ( ( 2 +( b * 8 )) , 3 + a )  ;
  textcolor ( white ) ;
  write ( answer3:4:2) ;
  gotoxy(  2 + (a * 8 ) ,( 3 +  b  ) );
  write ((1 / answer3):4:2 ) ;
end ;
```

```
    window ( 1,y1+1,80,23) ;
    textbackground ( 14 ) ;
    textcolor ( black ) ;
    if answer = 'n' then
    begin
      gotoxy ( 1,3 );
      write (  '  how many times is ',criteria2,' better than
             ', criterial , '   ?   ');
      Gotoxy (1,4) ;
      write ( '   ( see note below ) ' ) ;
      info1 ;
      repeat
        gotoxy(64,3 ) ;
        clreol ;
        read ( answer ) ;
        val   ( answer , answer3 , code ) ;
      until ( (  code = 0 ) and ( answer3 <> 0 ) )    ;
      matrix2[a,b] :=(1/ answer3) ;
      matrix2[b,a] :=     answer3  ;
      matrix2[a,a]    := 1 ;
      window ( 1,1,x1,y1) ;
      textcolor ( white ) ;
      textbackground ( blue ) ;
      gotoxy   ( ( 2 +( b  * 8 ) ), 3 + a )   ;
      write ((1/ answer3):4:2) ;
      gotoxy(  2 +.(a * 8 ) ,( 3 + b  ) );
      write ( answer3:4:2 ) ;
    end ;
    window ( 1,y1+1,80,23) ;
    textbackground ( 14 ) ;
    gotoxy (1,2 ) ;
    clreol ;
    gotoxy (1,3 ) ;
    clreol ;
    gotoxy (1,4) ;

    clreol ;
    goto ert
    end ;

    window(1,1,80,25);
    gotoxy(1,24);

END ;


OVERLAY PROCEDURE EVALUATE3 ( VAR ALTERNATIVES : TITLE1 ;
                              VAR  ALTVECTOR3 :VECTORF ;
                              VAR  W : INTEGER   ;
                              VAR  NORMVECTOR1 : VECTORG ;
                              var  ax : integer  ) ;
```

```
LABEL
   ert,ert4 ;

CONST
   count = 3 ;

VAR

   matrix2,result,matrix3 : array [1..20,1..20] of real ;
   array5,altvector5,exchange3,altvector6 : vectorf ;
   lamda1,vector2 : vectorf ;
   exchange4 ,alternativesk : title1 ;
   numofalternatives,I,count1,x1,y1,a1,b1,
   a3,b3,c3,d3,h3,k3,f3,p3,l : integer ;
   score,answer3,integer1,row,row1,
   lamda,ci,ri,cr : real ;
   st : string [9] ;
   ch : char;

PROCEDURE INFO1 ;
begin
  window (1,y1+1,80,23);
  textbackground (14) ;
  textcolor( red ) ;
  gotoxy(1,8) ;
  writeln ( '"note : be as accurate as possible
            any # between 0 and 10 e.g ,2.45 or 9.34 ' );
  Writeln ( ' a possible scale for inexact is : ' ) ;
  writeln ( ' 3 = weakly important than ,5 = strongly more
              importan than ') ;
  writeln ( ' 7 = very strongly more imp.than  9 =
    absolutely more imp. than');
  Textcolor ( black ) ;
end ;


BEGIN

  numofalternatives := w ;

  case numofalternatives of
     1,2,3,4,5,6,7 : begin

                       x1 := 50 ; y1 :=12 ;
                     end ;
     8,9,10,11     : begin
                       x1 := 55 ; y1 :=13 ;
                     end ;
     12,13,14,15   : begin
                       x1 := 70 ; y1 :=15 ;
                     end ;
end ;

numofalternatives := w ;
if numofalternatives <> 0  then
begin
  window (1,1,x1,y1);
  textbackground(blue);
  clrscr;

  window (x1+1,1,80,y1);
  textbackground(white) ;
  clrscr ;

  window (1,y1+1,80,23);
  textbackground(14) ;
  clrscr ;

  window ( 1,24,80,25) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy (2,1) ;
  write ('step  5:direct input of alternatives weights') ;
  altvector5 := altvector3 ;

  window (x1+1,1,80,y1);
  textbackground ( white ) ;
  textcolor( 0 ) ;
  gotoxy (1,1) ;
  write ( '   priority vector ' ) ;
  for a1 := 1 to numofalternatives do
  begin
    gotoxy ( 2 ,3 +a1 );
    write (copy( alternatives[a1],1,18) ) ;
  end ;
  for a := 1 to  numofalternatives  do
  begin
    gotoxy(20,3 + a ) ;
    write ( chr ( 179 ) ) ;
  end ;
  for a := 1 to  numofalternatives  do
  begin

    gotoxy(27,3 + a ) ;

    write ( chr ( 179 ) ) ;
  end ;

  window (1,y1+1,80,23);
  textbackground(14) ;
  clrscr ;
```

```
ert:
  info1 ;
  textcolor ( 0 ) ;
  gotoxy ( 2,2) ;
  write ( 'enter the weights of the alternatives : ' ) ;
  for a := 1 to  numofalternatives  do
  begin
   gotoxy ( 2 , 2+a ) ;
   write  ( alternatives[a] , ' : ') ;
  end;

  for a := 1 to  numofalternatives  do
  begin
   repeat
    gotoxy ( length(alternatives[a])+5 , 2+a ) ;
    clreol ;
    read ( answer ) ;
    val  ( answer . answer3 , code ) ;
   until((code = 0)and(answer3>-1) and (answer3 < 11));
   altvector5[a] := answer3 ;
  end ;
  row1 := 0 ;
  for p3 := 1 to  numofalternatives  do
    row1 := row1 + altvector5[p3] ;
  for p3 := 1 to  numofalternatives do
  begin
   altvector5[p3] := altvector5[p3] / row1 ;
  end ;

  window (51,1,80,21);
  textbackground ( white ) ;
  for a := 1 to  numofalternatives  do
  begin
   gotoxy(22,a+3) ;
   write ( altvector5[a]:5:3 ) ;
  end ;

  window (1,13,80,23 );
  textbackground(14) ;
  clrscr ;

  altvector3 := altvector5 ;
  alternativesk := alternatives ;

  repeat
   count1 := 0 ;


   for a := 1 to ( numofalternatives-1)  do
   begin
    if altvector5[a] < altvector5[a+1]  then
    begin
      exchange3[a] := altvector5[a] ;
      altvector5[a] := altvector5[a+1] ;
      altvector5[a+1] := exchange3[a] ;
      exchange4[a] := alternatives[a] ;
      alternatives[a] := alternatives[a+1] ;
      alternatives[a+1] := exchange4[a] ;
      count1 := count1 + 1 ;
    end ;
  end;
until  count1 = 0 ;

for a := 1 to ( numofalternatives )  do
begin
  gotoxy ( (  ( 5 *  a )) , 9  ) ;
  write (copy( alternatives[a],1,3) ) ;
end ;
for a := 1 to ( numofalternatives )  do
begin
  gotoxy ( (  ( 5 *  a )) , 10  ) ;
  write (altvector5[a]:3:2) ;
end ;

textbackground ( green ) ;
for a := 1 to ( numofalternatives )  do
begin
  gotoxy ( ( 5 * a ),8 ) ;
  write ( '    ' ) ;
end ;
for a := 1 to ( numofalternatives )  do
begin
  gotoxy ( (5 + ( 5 * a )) ,9 ) ;
  for b1 := 1 to   round ( altvector5[a] * 10 )    do
  begin
    gotoxy ( ( ( 5 * a )) ,(9 -b1) ) ;
    write ( '    ') ;
  end ;
end ;

gotoxy (2,11);
textbackground ( 14 ) ;
textcolor ( blue ) ;
write(' do you want to modify the evaluation of the
        alternatives (y/n) ? ') ;
Repeat
  gotoxy( 65,11 ) ;
  clreol ;
  read ( answer ) ;
  answer := stupcase ( answer ) ;
until  ( ( answer = 'y') or ( answer = 'n' ) ) ;
```

```
    window (1,13,80,23 );
    textbackground(14) ;
    if answer = 'y' then
    begin
      clrscr ;
      goto ert ;
    end ;
  end ;


  alternatives := alternativesk ;

END ;



OVERLAY PROCEDURE DIRECT2A ( VAR  ALTERNATIVES : TITLE1 ;
                             VAR  ALTVECTOR3 : VECTORF ;
                             VAR  W : INTEGER ;
                             VAR  NORMVECTOR1 : VECTORG ;
                          VAR  AX : INTEGER ) ;
LABEL
  ert9,telos9x ;

CONST
  count = 3 ;

VAR

  matrix2,result,matrix3 : array [1..20,1..20] of real ;
  array5,altvector5,exchange3,altvector6 : vectorf ;
  lamda1,vector2 : vectorf ;
  exchange4 ,alternativesk : title1  ;
  tempgrade,tempgrade1 : vectorf ;
  numofalternatives,I,count1,x1,y1,a1,b1,limit.x2,y2,
  a3,b3,c3,d3,h3,k3,f3,p3,l : integer ;
  score,answer3,integer1,row,
  row1,lamda,ci,ri,cr,count3 : real ;
  st : string [9] ;
  ch : char;


BEGIN

  numofalternatives := w ;
  case numofalternatives of
     1,2,3,4,5,6,7   : begin
                         x1 := 50 ; y1 :=12 ;
                       end ;
     8,9,10,11       : begin
                         x1 := 55 ; y1 :=13 ;
```

```
                        end ;
    12,13,14,15       : begin
                          x1 := 70 ; y1 :=15 ;
                        end ;
end ;

numofalternatives := w ;
if numofalternatives <> 0  then
begin
  window (1,1,x1,y1);
  textbackground(blue);
  clrscr;

  window (x1+1,1,80,y1);
  textbackground(white) ;
  clrscr ;

  window (1,y1+1,80,23):
  textbackground(14) ;
  clrscr ;

  window ( 1,24,80,25) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy (2,1) ;
  write('step 4 : individual evaluation of alternatives) ;
  gotoxy ( 2,2 ) ;
  write ( 'method used : direct input ' ) ;

  window (1,1,x1,y1);
  textbackground ( blue ) ;
  textcolor ( white ) ;
  gotoxy ( 2,1) ;
  write ( ' altern.Evaluation : working area ' ) ;
  for a := 1 to numofcriteria  do
  begin
    answer := normvector1[a] ;
    delete ( answer,4,length(answer) ) ;
    gotoxy ( 2,a+3) ;
    write (  answer:4 ) ;
  end ;
  for a := 1 to numofalternatives  do
  begin
    answer := alternatives[a] ;
    delete ( answer,4,length( answer)) ;
    gotoxy ( 9 + ( 5*(a-1)),3) ;
    write  ( answer ) ;
  end ;

  window (x1+1,1,80,y1);
```

```
textbackground ( white ) ;
textcolor( 0 ) ;
gotoxy (1,1) ;

write ( '   priority vector ' ) ;
for a1 := 1 to numofalternatives do
begin
  gotoxy ( 2 ,3 +a1 );
  write (copy( alternatives[a1],1,18) ) ;
end ;
for a := 1 to  numofalternatives  do
begin
  gotoxy(20,3 + a ) ;
  write ( chr ( 179 ) ) ;
end ;
for a := 1 to  numofalternatives  do
begin
  gotoxy(27,3 + a ) ;
  write ( chr ( 179 ) ) ;
end ;

window (1,y1+1,80,23);
textbackground(14) ;
clrscr ;
for a := 1 to numofcriteria  do
begin
  if norm.specialized Then
  begin
    if specfile2.normindex[a] <> namex   Then
       goto telos9x ;
  end ;
  gotoxy ( 2,2) ;
  write ( '**   evaluate alternative according to
    criteria',normvector1[a],'   : ' ) ;
  for b := 1 to numofalternatives  do
  begin
    window (1,y1+1,80,23);
    textbackground(14) ;
    textcolor ( black ) ;
    gotoxy ( 5,b+3) ;
    write (b ,' -  for alternative  ', alternatives[b] ,
           '  any value between 0 and 10  ?  ' ) ;
    X2 := 76 ; y2 := b + 3 ; count3 := 0 ; limit := 10 ;
    checknumber ( answer,x1,y1,limit,count3 ) ;
    tempgrade1[b] := count3 ;
    window (1,1,x1,y1);
    textbackground ( blue );
    textcolor ( white ) ;
    gotoxy ( 9 + ( 5*(b-1)),3+a) ;
    write ( tempgrade1[b]:3:2 ) ;
  end ;
```

```
ert9:
      tempgrade := tempgrade1 ;
      (* normilize vector *)
      row := 0 ;
      for p3 := 1  to numofalternatives  do
          row := row + tempgrade[p3] ;

      for p3 := 1 to  numofalternatives  do
          tempgrade[p3] := tempgrade[p3] / row ;
      window ( x1 + 1 ,1,80,y1 ) ;
      textbackground ( white ) ;
      textcolor ( black ) ;
      for a1 := 1 to numofalternatives do
      begin
        gotoxy ( 22,a1+ 3 ) ;
        write ( tempgrade[a1]:3:2 ) ;
      end ;
      window (1,y1+1,80,23);
      textbackground(14) ;
      clrscr ;
      for a1 := 1 to numofalternatives  do
      begin
        gotoxy ( (  ( 5 *  a1 )) , 10  ) ;
        write ( copy( alternatives[a1],1,3)  ) ;
      end ;
      for a1 := 1 to numofalternatives  do
      begin
        gotoxy ( (  ( 5 *  a1 )) , 11  ) ;
        write ( tempgrade[a1]:3:2 ) ;
      end ;

      textbackground ( green  ) ;
      for a1 := 1 to  numofalternatives   do
      begin
        gotoxy ( (5 + ( 5 * a1 )) ,9 ) ;
        for b1  := 1 to  round  (  tempgrade[a1] * 10 )   do
       begin
          gotoxy ( ( ( 5 * a1 )) ,(9 -b1) ) ;
          write ( '   ') ;
        end ;
      end ;
      textbackground ( 14 ) ;
      textcolor ( black ) ;
      gotoxy ( 36,11) ;
      write ('do you want to modify the weights (y/n)? ' ) ;
      repeat
        gotoxy ( 78,11);
        clreol ;
        read ( answer ) ;
        answer := stupcase(answer) ;
      until ( ( answer = 'Y') or ( answer = 'n' ) ) ;
```

```
if answer = 'y' then
begin
  clrscr ;
  error := false ;
  repeat
    gotoxy (2,2) ;
    clreol ;
    write ( 'name of the alternative ? ' ) ;
    read ( answer ) ;

    answer := stupcase ( answer ) ;
    for a1 := 1 to numofalternatives do
    begin
      if answer = alternatives[a1] then
         error := true ;
    end ;
  until error ;
  a1 := 0 ;
  repeat
    a1 := a1 + 1
  until answer = alternatives[a1] ;
  clrscr ;

  Window (1,1,x1,y1);
  textbackground ( blue );
  textcolor ( red ) ;
  gotoxy ( 9 + ( 5*(a1-1)),3+a) ;
  write ( tempgrade1[a1]:3:2 ) ;

  window (1,y1+1,80,23);
  textbackground(14) ;
  textcolor(black ) ;
  gotoxy ( 2,2) ;
  write ( 'for alternative  ', alternatives[a1] ,
         '  any value between 0 and 10  ?  ' ) ;
  X2 := 76 ; y2 := b + 3 ; count3 := 0 ; limit := 10 ;

  checknumber ( answer,x1,y1,limit,count3 ) ;
  tempgrade1[a1] := count3 ;

  window (1,1,x1,y1);
  textbackground ( blue );
  textcolor ( white ) ;
  gotoxy ( 9 + ( 5*(a1-1)),3+a) ;
  write ( tempgrade1[a1]:3:2 ) ;

  goto ert9 ;
end;

for a1 := 1 to  numofalternatives   do
    altmatrix[a,a1] := tempgrade[a1] ;
```

```
      window (1,y1+1,80,23);
      textbackground ( 14 );
      textcolor ( black ) ;
      clrscr ;
telos9x:
    end ;
  end ;
```

```
END ;
```

INCLUDE FILE 4-2

OVERLAY PROCEDURE ELECTRE ;

```
TYPE

  scale  = array[1..4] Of name :
  ind    = array[1..9] Of integer ;
  aray2  = array[1..5,1..9] Of real ;

VAR

  f1,f2,a,b,c,limit : integer ;
  sum,result,pfactor,
  qfactor,max,min,count3 : real ;
  discordance,concordance,
  matrixdance,matrixcon : matrix20 ;
  outranking : array9;
  criteria : vectorg ;
  critvalue : vectorn ;
  alter : title1 ;
  grading : aray1 ;
  gradingweight : aray2 ;
  index,cindex,dindex : ind ;
  st1 : name ;


PROCEDURE WRITEWORKSHEET ;
BEGIN
  window ( 1,1,41,12) ;
  textbackground ( blue );
  textcolor ( white );

  gotoxy ( 2,1) ;
  write ( ' altern.Evaluation : working area ' ) ;

  for a := 1 to numofcriteria  do
  begin
    answer := criteria[a] ;
    delete ( answer,4,length(answer) ) ;
    gotoxy ( 5 + ( 4*(a-1)),3) ;
    write (  answer:4 ) ;
  end ;

  for a := 1 to numofalternatives  do
  begin
    gotoxy ( 2,a+3) ;
    answer := alter[a] ;
    delete ( answer,4,length( answer)) ;
    write  (  answer:3 ) ;
  end ;
END ;


PROCEDURE GRADES ;
VAR

 base,step : real  ;

BEGIN
  for a := 1 to numofcriteria do
  begin
    base := critvalue[a] * 100 ;
    step := base  / 4 ;
    for b := 1 to 5 do
        gradingweight[b,a] := base - ( step * ( b -1) ) ;
  end ;
END ;


PROCEDURE WRITEGRADING ;
BEGIN
  window (41,1,80,12) ;
  textbackground ( white );
  textcolor ( black ) ;
  gotoxy ( 2,1) ;
  write ( 'grading scale ' ) ;

  for a := 1 to numofcriteria  do
  begin
    gotoxy ( 7 + ( 4*(a-1)),3) ;
    answer := criteria[a];
    delete ( answer,4,length( answer) ) ;
    write (  answer:4 ) ;
  end ;

 gotoxy(1,4);
 textcolor ( red ) ;
 write ( 'weig.:') ;

 For a := 1 to numofcriteria do
 begin
```

```
   gotoxy( 4 + ( 4*a),4) ;
   write ( round(critvalue[a]*100) )  ;
 end ;
 textcolor( black ) ;
 gotoxy ( 1,6  ) ;
 write  ( 'exce' ) ;
 gotoxy ( 1,7  ) ;
 write ( 'good'  );
 gotoxy(1,8);
 write ( 'aver');
 gotoxy ( 1,9);
 write('fair') ;
 gotoxy(1,10) ;
 write('weak') ;
 grades ;

 for a := 1 to numofcriteria  do
 begin
   for b := 1 to 5  do
   begin
     gotoxy ( 4 + ( 4*a), b + 5 ) ;
     write ( round(gradingweight[b,a]) ) ;
 end;
END ;


PROCEDURE GRADEALTERNATIVES ;

LABEL

  jmp3 ;

BEGIN

  window ( 1,13,80,24) ;
  textbackground ( 14 );
  textcolor ( black ) ;
  if norm.specialized  Then
     grading := specfile2.grading ;
  For a := 1 to numofalternatives do
  begin
    gotoxy ( 2,2) ;
    write ( '** evaluate alternative ', alter[a] , '   : ' );
    for b := 1 to numofcriteria  do
    begin
      if norm.specialized  Then
      begin
        if specfile2.normindex[b] = namex  Then
           goto jmp3 ;
      end ;
      write (b ,' - for criterion ',criteria[b],'any value
                between 0 and ',round(gradingweight[1,b]),'?');
           X1 := 76 ;
           y1 := b + 3 ;
           count3 := 0 ;
           limit := round( gradingweight[1,b]) ;
           checknumber ( answer,x1,y1,limit,count3 ) ;
           grading[a,b] := count3 ;
           window ( 1,1,40,12) ;
           textbackground ( blue );
           gotoxy( 2 + ( 4*b),a+3) ;
           write (round(grading[a,b])) ;
           window ( 1,13,80,23) ;
           textbackground ( 14 );
jmp3:
     end ;
     clrscr ;
  end ;
END ;

PROCEDURE FACTORS ;
BEGIN
   window ( 1,13,80,23) ;
   textbackground ( 14 );
   clrscr ;
   textcolor ( black ) ;
   gotoxy ( 2,4) ;
   write ( '**  concordance threshold (p) [0 - 100]  :  ' ) ;
   gotoxy ( 2,5) ;
   write ( '( nb . becomes severe as it approaches 100)? ') ;
   X1 := 70 ; y1 := 5 ; count3 := 0 ; limit := 100 ;
   checknumber ( answer,x1,y1,limit,count3 ) ;
   pfactor := count3 ;
   gotoxy ( 2,7) ;
   write ( '**  discordance threshold (q) [0 - 100]  :  ' ) ;
   gotoxy ( 2,8) ;
   write ('(nb .. becomes severe as it approaches 100 )? ') ;
   X1 := 70 ; y1 := 8 ;
   count3 := 0 ; limit := 100 ;
   checknumber ( answer,x1,y1,limit,count3 ) ;
   qfactor := count3 ;
   if ((specfile2.pfactor <> 0) And
       (specfile2.Pfactor <pfactor)) then
          pfactor := specfile2.pfactor ;
   If ((specfile2.qfactor <> 0 ) And
       ( specfile2.Qfactor > qfactor ) ) then
          qfactor := specfile2.qfactor ;

  Window (41,1,80,12) ;
  textbackground ( white );
  textcolor ( black ) ;
  gotoxy ( 2,11 ) ;
```

```
 write ('p = ',pfactor:3:2,' %  q = ', qfactor:3:2,' % ' ) ;
 if norm.specialized Then
 begin
   specfile2.pfactor := pfactor ;
   specfile2.qfactor := qfactor ;
   specfile2.grading := grading ;
   A := 0 ;
   repeat
     a := a + 1 ;
   until ( namex = norm.Usersnames[a] ) ;
   specfile2.Finalindex1[a] := true ;
   writespecfile ;
 end ;
END ;


PROCEDURE COMPUTE1 ;
BEGIN
  for c := 1 to numofcriteria  do
  begin
    if  ( grading [a,c] >= grading[b,c] ) then

         sum := sum + critvalue[c] ;
  end ;
  if  ( a  <>  b ) then
      concordance[a,b] := sum * 100
  else
    concordance[a,b] := 1 ;
 END ;


PROCEDURE COMPUTE2 ;
BEGIN
  for c := 1 to numofcriteria  do
  begin
    if ( grading[b,c] > grading[a,c] ) then
         sum := grading[b,c] - grading[a,c] ;
    if  ( result <= sum ) then
         result := sum ;
  end ;
  if  ( a  <>  b ) then
     discordance[a,b] := result / critvalue[1]
  else
     discordance[a,b] := 1 ;
END ;


PROCEDURE COMPUTECONC ;
BEGIN
  for a := 1 to numofalternatives  do
```

```
   begin
     for b := 1 to numofalternatives do
     begin
       sum := 0 ;
       compute1 ;
     end ;
  end ;
END ;


PROCEDURE FINTINDEX1 ;
BEGIN
   for a := 1 to numofalternatives  do
   begin
     c := 0 ;
     for b := 1 to numofalternatives do
     begin
       if concordance[a,b] >= pfactor  then
          c := c + 1;
       cindex[a] := c ;
     end ;
   end ;
   f1 := 0 ;

   for a := 1 to numofalternatives do
       f1 := f1 + cindex[a] ;
END ;


PROCEDURE COMPUTEDISCONC ;
BEGIN
   for a := 1 to numofalternatives  do
   begin
     for b := 1 to numofalternatives do
     begin
       sum := 0 ;
       result := 0 ;
       compute2 ;
     end ;
   end ;
END ;


PROCEDURE FINTINDEX2 ;
BEGIN
   for a := 1 to numofalternatives  do
   begin
     c := 0 ;
     for b := 1 to numofalternatives do
```

```
    begin
      if discordance[a,b] <= qfactor  then
         c := c + 1;
      dindex[a] := c - 1 ;
    end ;
  end ;
  f2 := 0 ;
  for a := 1 to numofalternatives do
      f2 := f2 + dindex[a] ;
END ;


PROCEDURE WRITEALT (var st1:name ; var matrixcon :matrix20 ;
                     var index : ind );

BEGIN
  for a := 1 to numofalternatives  do
  begin
    answer := alter[a] ;
    delete ( answer,4,length( answer) ) ;
    gotoxy( 2,a + 3) ;
    write ( answer:4 ) ;
  end ;
  for a := 1 to numofalternatives  do
  begin
    answer := alter[a] ;

    delete ( answer,4,length( answer) ) ;
    gotoxy ( 5 + ( a * 5 ) , 3 ) ;
    write ( answer:3 ) ;
  end ;
  textcolor ( red ) ;
  gotoxy ( 5 + (( a+1) * 5 ) , 3 ) ;
  write ( st1 ) ;
  textcolor ( black ) ;

  for a := 1 to numofalternatives do
  begin
    for b := 1 to numofalternatives do
    begin
      gotoxy ( 5 + ( b * 5) , a + 3 ) ;
      if  ( a = b ) then
           write ( '-' )
      else
        write ( round(matrixcon[a,b]) ) ;
    end ;
 end ;

 textcolor ( red ) ;
 for c := 1 to numofalternatives  do
```

```
  begin
    gotoxy ( 5 + ( (b+1) * 5) ,c + 3 ) ;
    write ( index[c] ) ;
  end ;
  textcolor ( black ) ;
END ;



PROCEDUTE CONFINT ;
BEGIN
   window ( 1,13,80,23) ;
   textbackground ( 14 );
   textcolor ( blue ) ;
   clrscr ;
   gotoxy ( 2,2) ;
   write ('concordance matrix ' ) ;
   computeconc ;
   fintindex1 ;
   textcolor ( black ) ;

   st1 := '#ci';
   matrixcon := concordance ;
   index := cindex ;

   writealt ( st1 ,matrixcon,index ) ;
   textcolor ( blue ) ;
   gotoxy ( 38,2) ;
   write ('**  a concordance index indicates to ' ) ;
   gotoxy ( 38,3) ;

   write ('     what extent an option is better than ') ;
   gotoxy ( 38,4) ;
   write ('     another in terms of criteria weights ');
   gotoxy ( 38,5) ;
   write ('**  the index varies between [ 0 - 100 ] ' );
   gotoxy ( 38,6 ) ;
   write ('     the higher the better . ' ) ;
   Gotoxy ( 38,7) ;
   write ('    ',f1,'  indexes are > =  ',round(pfactor)) ;
   gotoxy ( 38,8) ;
   write ('**   column #ci indicates the # of indexes ' ) ;
   gotoxy ( 38,9 ) ;
   write ('      satisfying  p for each option ' ) ;
   gotoxy ( 2,10 ) ;
   write ( 'hit any key to continue ' ) ;
   read ( kbd,ch ) ;
END ;
```

```
PROCEDURE DISFINT ;

BEGIN
  window ( 1,13,80,23) ;
  textbackground ( 14 );
  clrscr ;
  textcolor ( blue ) ;
  gotoxy ( 2,2) ;
  write ('discordance matrix ' ) ;
  computedisconc ;

  fintindex2 ;
  textcolor ( black ) ;

  st1 := '#di';
  matrixcon := discordance ;
  index := dindex ;
  writealt ( st1 ,matrixcon,index ) ;
  textcolor ( blue ) ;
  gotoxy ( 40,2) ;
  write ('**  a discordance index indicates to ' ) ;
  gotoxy ( 40,3) ;
  write ('     what extent an option contains a bad ') ;
  gotoxy ( 40,4) ;
  write ('     element that makes it un-satisfactory  ');
  gotoxy ( 40,5) ;
  write ('**  the index varies between  [ 0 - 100 ] ');
  gotoxy ( 40,6 ) ;
  write ('     the lower the better . ' ) ;
  Gotoxy ( 40,7) ;
  write ('    ',f2,'  indexes are ( =  ',qfactor:3:2 ) ;
  gotoxy ( 40,8) ;
  write ('**   column #ci indicates the # of indexes '  ) ;
  gotoxy ( 40,9 ) ;
  write ('      satisfying  q for each option ' ) ;

  gotoxy ( 2,10) ;
  write ( 'hit any key to continue ' ) ;
  read ( kbd,ch ) ;
END ;

PROCEDURE COMPUTEOUTRANKING ;
BEGIN
  for a := 1 to numofalternatives do
  begin
    for b := 1 to numofalternatives do
    begin
      if ( ( concordance[a,b] >= pfactor ) and
           ( discordance[a,b] <= qfactor )       )  then
             outranking[a,b] := '*'
      else
```

```
        outranking[a,b] := '-' ;
    end ;
  end ;
  for a := 1 to numofalternatives  do
      outranking[a,a] := '-' ;
END ;

PROCEDURE OUTFINT ;
VAR
  ans : name ;
BEGIN
  window ( 1,13,80,23) ;
  textbackground ( 14 );
  textcolor ( blue ) ;
  clrscr ;
  gotoxy ( 2,2) ;
  write ('outranking matrix ' ) ;
  computeoutranking ;
  textcolor ( black ) ;
  for a := 1 to numofalternatives  do
  begin
    ans := alter[a] ;
    delete ( ans,4,length( ans) ) ;
    gotoxy( 2,a + 3) ;
    write ( ans:4 ) ;
  end ;
  for a := 1 to numofalternatives  do
  begin
    ans := alter[a] ;
    delete ( ans,4,length( ans) ) ;
    gotoxy ( 5 + ( a * 5 ) , 3 ) ;
    write ( ans:3 ) ;
  end ;
  for a := 1 to numofalternatives do
  begin
    for b := 1 to numofalternatives do
    begin
      gotoxy ( 5 + ( b * 5) , a + 3 ) ;

      write (outranking[a,b] ) ;
    end ;
  end ;

  textcolor ( blue ) ;
  gotoxy ( 38,2) ;
  write ('**  an outranking relation * is the  ' ) ;
  gotoxy ( 38,3) ;
  write ('    one that satisfies both concordance  ') ;
  gotoxy ( 38,4) ;
  write ('    and discordance requirements. ');
  Gotoxy ( 38,5) ;
  write ('**  an  -  indicates that there is  ' );
  gotoxy ( 38,6 ) ;
  write ('    no outranking relations.  ' ) ;
  Gotoxy ( 2,10 ) ;
  write ( 'hit any key to continue ' ) ;
  read ( kbd,ch ) ;
END ;

BEGIN (* main *)

  window ( 1,1,40,12) ;
  textbackground ( blue );
  clrscr ;

  window (41,1,80,12) ;
  textbackground ( white );
  clrscr ;

  window ( 1,13,80,23) ;
  textbackground ( 14 );
  clrscr ;

  window ( 1,24,80,25) ;
  textbackground ( white );
  clrscr ;
  textcolor ( black ) ;
  gotoxy ( 2,1) ;
  write ( 'step 4 : evaluation of alternatives ' ) ;
  gotoxy( 2,2) ;
  write ( 'method used : electre ' ) ;

  if ( not norm.Specialized ) then
  begin
    alter := problem.alternatives ;
    numofalternatives := problem.numofalternatives ;
    criteria := solution.normvector1 ;
    critvalue := solution.normvector2 ;
  end
  else
  begin
    alter := problem.alternatives ;

    numofalternatives := problem.numofalternatives ;
    criteria := Specfile2.normvector1 ;
    critvalue := Specfile2.normvector2 ;
  end ;

  writewoksheet ;

  writegrading ;
  gradealternatives ;

  factors ;

  if norm.specialized Then
  begin
    b := 0 ;
    for a := 1 to 3 do
    begin
      if specfile2.finalindex1[a]  Then
         b := b + 1 ;
  end ;
  if ( b = norm.Numofusers ) then
      specfile2.Electre.Status := true
  else
    specfile2.Electre.Status := false ;
  end ;

  if (  ( not norm.Specialized ) or
     (  norm.Specialized  and  specfile2.Electre.Status )   )
then   begin
    repeat
      window ( 1,13,80,23) ;
      textbackground ( 14 );
      clrscr ;
      textcolor( black ) ;
      gotoxy( 2,2) ;
      write ( 'menu ' ) ;
      gotoxy(2,4) ;
      write ( '1. Concordance matrix  ' ) ;
      gotoxy(2,5) ;
      write ( '2. Discordance matrix  ' ) ;
      gotoxy( 2,6) ;
      write ( '3. Outranking matrix ' ) ;
      gotoxy( 2,7) ;
      write ( '4. Modify thresholds ' ) ;
      gotoxy( 2,8) ;
      write ( '5. Exit electre ' ) ;
      gotoxy ( 2,10) ;
      write ( 'selection (1-5) ? ' ) ;
      Repeat
        gotoxy( 30,10);
        clreol ;
        read ( answer ) ;

      until ((answer ='1') or (answer = '2') or (answer =
           '3') or (answer = '4') or (answer = '5') ) ;
       if answer = '1' then
         confint ;

      if answer = '2' then
     isfint ;
     if answer = '3' then
     begin
       computeconc ;
       computedisconc ;
       outfint ;
     end ;

     if answer = '4' then
        factors ;
   until ( answer = '5' ) ;

   if ( not norm.Specialized )  then
   begin
     solution.Electre.Outranking := outranking ;
     writesolutionfile ;
   end
   else
   begin
     specfile2.Electre.Outranking := outranking ;
     writespecfile  ;
   end ;
 end ;
END ;
```

INCLUDE FILE STEP6

```
OVERLAY PROCEDURE GDSS ;

LABEL

  telos1 ;

TYPE

 names = name ;
 altnames1 = array[1..20] Of names ;
 altvector5 = array[1..6,1..20] Of real ;
 ordinal2 = array [1..20] Of integer ;
 ordinal3 = array [1..6] Of ordinal2 ;


VAR

  a,b,c,numofalternatives,resultx,numofusers ,xxx ,
  countahp,countelectre,suma ,count12,f1 : integer ;
```

```
    filname1,xx,pruser1 : names ;
    altvector6 : array [1..6] of vectorf ;
    altnames : array [1..6] of title1 ;
    usersnames : name2    ;
    answer6,userx : names ;
    br2,altvector8,ar2,ar3 : vectorf ;
    altnames6 : title1 ;
    br1,ordinal1,ar1,ar4,individualordinal1,
    individualvector1 : ordinal2 ;
    ordinal,individualordinal,individualvector : ordinal3 ;
    resultx1,resultx2 : real ;
    weight : vectors1 ;
    ch : char ;
    indexm : array[1..9] Of char ;


PROCEDURE COMPUTE1 ;
BEGIN
  for b := 1 to numofalternatives do
  begin
    suma := 0;
    for c := 1 to numofusers do
    begin
      ordinal1 := ordinal[c] ;
      suma := suma + ordinal1[b] ;
    end ;
    ar1[b] := suma ;
  end ;
  for a := 1 to  numofalternatives do
  begin
    gotoxy ( 6,a+5 ) ;
    write ( ar1[a] );
  end ;
END ;



PROCEDURE COMPUTE2 ;
BEGIN
  for b := 1 to numofalternatives do
  begin
    resultx1 := 0;
    for c := 1 to numofusers do
    begin
      altvector8 := altvector6[c] ;
      resultx1 := resultx1 + altvector8[b] ;
    end ;
    ar2[b] := ( resultx1 / numofusers ) ;
  end ;

  for a := 1 to  numofalternatives do
  begin
    gotoxy (12,a+5 ) ;
    write ( ar2[a]:3:2 );
  end ;
END ;

PROCEDURE COMPUTE3 ;
BEGIN
  for b := 1 to numofalternatives do
  begin
    resultx1 := 1;
    for c := 1 to numofusers do
    begin
      altvector8 := altvector6[c] ;
      resultx1 := resultx1 * altvector8[b] ;
    end ;
    resultx2 := ln ( resultx1 ) ;
    ar3[b] := exp (  ( 1 / numofusers ) * resultx2   ) ;
  end ;
  for a := 1 to  numofalternatives do
  begin
    gotoxy ( 18,a+5 ) ;
    write ( ar3[a]:3:2 );
  end ;
END ;

PROCEDURE COMPUTE4 ;
BEGIN
  for b := 1 to numofalternatives do
  begin
    suma := 0;
    for c := 1 to numofusers do
    begin
      ordinal1 := ordinal[c] ;
      suma :=  suma +( numofalternatives -  ordinal1[b] ) ;
  end ;
    ar4[b] := suma ;
  end ;
  for a := 1 to  numofalternatives do
  begin
    gotoxy ( 24,a+5 ) ;
    write ( ar4[a] );
  end ;
END ;

PROCEDURE COMPUTEORDINAL ;
BEGIN
  for b := 1 to numofalternatives do
  begin
    suma := 1 ;
    for c := 1 to ( numofalternatives ) do
    begin

    if altvector8[b] < altvector8[c]   then
         suma := suma + 1 ;
    end ;
    ordinal1[b] := suma ;
  end ;
END ;

PROCEDURE COMPUTEINDIVIDUALVECTOR ;
BEGIN
  for a1 := 1 to numofalternatives do
  begin
    suma := 0 ;
    for b1 := 1 to numofalternatives do
    begin
      if ( solution.Electre.Outranking[a1,b1] = '*')    then
        suma := suma + 1 ;
    end ;
    individualvector1[a1] := suma ;
  end ;
END ;

PROCEDURE COMPUTEX1 ;
BEGIN
  for a := 1 to numofalternatives do
  begin
    suma := 0 ;
    for b := 1 to numofusers do
    begin
      individualvector1 := individualvector[b] ;
      suma := suma + individualvector1[a] ;
    end ;
    gotoxy ( 9,5+a ) ;
    write ( suma ) ;
  end ;
END ;

PROCEDURE COMPUTEX2 ;
BEGIN
  for a := 1 to numofalternatives do
  begin
    suma := 0 ;
    for b := 1 to numofusers do
    begin
      individualordinal1 := individualordinal[b] ;
      suma := suma + individualordinal1[a] ;
    end ;
    gotoxy (15,5+a ) ;
    write ( suma ) ;
  end ;
END ;
```

```
PROCEDURE WIN1 ;
BEGIN
  if  norm.Broadcasting then
  begin
    for a := 1 to numofusers do
    begin
      gotoxy ( 6 * a , 4 ) ;
      write ( usersnames[a]:4 ) ;
    end ;
    gotoxy ( 2,5) ;
    textcolor (red ) ;
    write ( 'weig.:' ) ;
    For a := 1 to numofusers do
    begin
      gotoxy ( (6*a)+2,5) ;
      write ( weight[a]:3:2 ) ;
    end ;
    textcolor ( blue ) ;
    for a := 1 to  numofalternatives do
    begin
      gotoxy ( 2,a+5 ) ;
      write ( copy(altnames6[a],1,3) );
    end ;
    for a := 1 to numofusers do
    begin
      altvector8 := altvector6[a] ;
      for b := 1 to numofalternatives do
      begin
        gotoxy (  (6 * a)+2 , b + 5 ) ;
        write ( altvector8[b]:3:2 ) ;
      end ;
   end ;
 end
 else
 begin
   for a := 1 to numofusers do
   begin
     if ( pruser1 = usersnames[a] ) then
     begin
       gotoxy ( 6  , 4 ) ;
       write ( usersnames[a]:4 ) ;
       xxx := a ;
     end ;
   end ;
   for a := 1 to  numofalternatives do
   begin
     gotoxy ( 2,a+5 ) ;
     write (copy( altnames6[a],1,3) );
   end ;
   altvector8 := altvector6[xxx] ;
   for b := 1 to numofalternatives do
```

```
    begin
      gotoxy ( 8   , b + 5 ) ;

      write ( altvector8[b]:3:2 ) ;
    end ;
  end ;
END ;

PROCEDURE WIN2 ;
BEGIN
  window (26,1,50,16 ) ;
  textbackground ( 14 ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy ( 2,2 ) ;
  write ( ' ordinal  ranking ' ) ;
  if norm.Broadcasting  then
  begin
    for a := 1 to numofusers do
    begin
      gotoxy (( 6*a)-2  ,4) ;
      write ( usersnames[a]:4 ) ;
    end ;
  end
  else
  begin
    gotoxy ( 6,4) ;
    write ( usersnames[xxx] ) ;
  end ;
  for a := 1 to numofusers  do
  begin
    altvector8 := altvector6[a] ;
    for b := 1 to numofalternatives do
    begin
      suma := 1 ;
      for c := 1 to ( numofalternatives ) do
      begin
        if altvector8[b] ( altvector8[c]  then
           suma := suma + 1 ;
      end ;
      ordinal1[b] := suma ;
    end ;
    ordinal[a] := ordinal1 ;
  end ;
  if norm.Broadcasting  then
  begin
    for a := 1 to numofusers do
    begin
      ordinal1 := ordinal[a] ;
      for b := 1 to numofalternatives do
      begin
```

```
        gotoxy ( 6 * a , b + 5 ) ;
        write ( ordinal1[b] ) ;
      end ;
    end ;
 end

 else
 begin
   ordinal1 := ordinal[xxx] ;
   for b := 1 to numofalternatives do
   begin
     gotoxy ( 6  , b + 5 ) ;
     write ( ordinal1[b] ) ;
   end ;
 end ;
END ;

PROCEDURE WIN3 ;
BEGIN
  window (51,1,30,16 ) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy ( 1,2 ) ;
  write ( ' group results ' ) ;
  for a := 1 to 4 do
  begin
    gotoxy (( 6*a),4) ;
    write ( 'r',a ) ;
  end ;
  for a := 1 to  numofalternatives do
  begin
    gotoxy ( 2,a+5 ) ;
    write ( copy (altnames6[a],1,3) );
  end ;
  if norm.Agregation  then
  begin
    computer1 ;
    computer2 ;
    computer3 ;
    computer4 ;
  end
  else
  begin
    f1 := 0 ;
    repeat
      f1  := f1 + 1 ;
      case  norm.Agregationname[f1]   of
            '2':  computer2 ;
            '1':  computer1 ;
            '4':  computer4 ;
            '3':  computer3 ;
      end ;
    until ( f1 )= 4 ) ;
  end ;
END ;



PROCEDURE WIN4 ;
BEGIN
  if  norm.Broadcasting then
  begin
    for a := 1 to numofusers do
    begin
      gotoxy ( 6 * a , 4 ) ;
      write ( usersnames[a]:4 ) ;
    end ;
    for a := 1 to  numofalternatives do
    begin
      gotoxy ( 2,a+5 ) ;
      delete( altnames6[a] , 4 ,length (altnames6[a]) ) ;
      write ( altnames6[a]  );
    end ;
    for a := 1 to numofusers do
    begin
      individualvector1 := individualvector[a] ;
      for b := 1 to numofalternatives do
      begin
        gotoxy ( (6 * a)+2 , b + 5 ) ;
        write (individualvector1[b] ) ;
      end ;
    end ;
  end
  else
  begin
    for a := 1 to numofusers do
    begin
      if ( pruser1 = usersnames[a] ) then
      begin
        gotoxy ( 6  , 4 ) ;
        write ( usersnames[a]:4 ) ;
        xxx := a ;
      end ;
    end ;
    for a := 1 to  numofalternatives do
    begin
      gotoxy ( 2,a+5 ) ;
      write ( altnames6[a] );
    end ;
    individualvector1 :=  individualvector[xxx] ;
    for b := 1 to numofalternatives do
    begin
      gotoxy ( 6  , b + 5 ) ;
      write (  individualvector1[b] ) ;
    end ;
  end ;
END ;




PROCEDURE WIN5 ;
BEGIN
  window (26,1,50,16 ) ;
  textbackground ( 14 ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy ( 2,2 ) ;
  write ( ' ordinal  rankink ' ) ;
  if norm.Broadcasting  then
  begin
    for a := 1 to numofusers do
    begin
      gotoxy ( 6*a  ,4) ;
      delete( usersnames[a]  , 4 ,length (usersnames[a]) ) ;
     write ( usersnames[a]  );
    end ;
  end
  else
  begin
    gotoxy ( 6,4) ;
    delete(usersnames[xxx], 4 ,length (usersnames[xxx])  ) ;
    write ( usersnames[xxx]  );
  end ;
  for a := 1 to numofusers  do
  begin
    individualvector1 := individualvector[a] ;
    for b := 1 to numofalternatives do
    begin
      suma := 1 ;
      for c := 1 to ( numofalternatives ) do
      begin
        if individualvector1[b] < individualvector1[c]  then
           suma := suma + 1 ;
      end ;
      individualordinal1[b] := suma ;
    end ;
    individualordinal[a] := individualordinal1 ;
  end ;
  if norm.Broadcasting  then
  begin
    for a := 1 to numofusers do
    begin
      individualordinal1 := individualordinal[a] ;
      for b := 1 to numofalternatives do
      begin
        gotoxy ( 6 * a , b + 5 ) ;
        write ( individualordinal1[b] ) ;
      end ;
    end ;
  end
  else
  begin
    individualordinal1 := individualordinal[xxx] ;

    for b := 1 to numofalternatives do
    begin
      gotoxy ( 6   , b + 5 ) ;
      write ( individualordinal1[b] ) ;
    end ;
  end ;
END ;


PROCEDURE WIN6 ;
BEGIN
  window (51,1,80,16 ) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy ( 1,2 ) ;
  write ( ' group results ' ) ;
  gotoxy ( 9 ,4) ;
  write ( 'r4' ) ;
  gotoxy ( 15,4) ;
  write ( 'r1' ) ;
  for a := 1 to  numofalternatives do
  begin
    gotoxy ( 2,a+5 ) ;
    write ( copy (altnames6[a],1,3) );
  end ;
  if norm.Agregation  then
  begin
    computex1 ;
    computex2 ;
  end
  else
  begin
    for f1 := 1  to  4  do
    begin
      case  norm.Agregationname[f1]   of
```

```
            '1': computex1 ;
            '4': computex2 ;
      end ;
    end ;
  end ;
END ;


PROCEDURE WIN7 ;
BEGIN
  gotoxy ( 2,2 ) ;
  write ( ' ordinal  ranking ' ) ;
  if norm.Broadcasting  then
  begin
    for a := 1 to numofusers do
    begin
      gotoxy ( (6*a)+2, 4) ;

      write ( copy(usersnames[a],1,3) ) ;
    end ;
    for a := 1 to  numofalternatives do
    begin
      gotoxy ( 2,a+5 ) ;
      write ( copy (altnames6[a],1,3) );
    end ;
  end
  else
  begin
    gotoxy ( 6,4) ;
    write ( usersnames[xxx] ) ;
  end ;
  if norm.Broadcasting  then
  begin
    for a := 1 to numofusers do
    begin
      ordinal1 := ordinal[a] ;
      for b := 1 to numofalternatives do
      begin
        gotoxy ( (6 * a)+2 , b + 5 ) ;
        write ( ordinal1[b] ) ;
      end ;
    end ;
  end
  else
  begin
    ordinal1 := ordinal[xxx] ;
    for b := 1 to numofalternatives do
    begin
      gotoxy ( 6  , b + 5 ) ;
  end ;
END ;
```

```
PROCEDURE WIN8 ;
BEGIN
  window (51,1,80,16 ) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black ) ;
  gotoxy ( 1,2 ) ;
  write ( ' group results ' ) ;
  for a := 1 to 4 do
  begin
    gotoxy ( 6*a  ,4) ;
    write ( 'r',a ) ;
  end ;
  for a := 1 to  numofalternatives do
  begin
    gotoxy ( 2,a+5 ) ;

    write ( copy(altnames6[a],1,3) );
  end ;
  if norm.Agregation  then
  begin
    computer1 ;
    computer4 ;
  end
  else
  begin
    for f1 := 1  to  4  do
    begin
      case   norm.Agregationname[f1]     of
             '1':   computer1 ;
             '4':  computer4 ;
      end ;
    end ;
  end ;
END ;

PROCEDURE WINDOW1 ;
BEGIN
  window (1,17,80,23 ) ;
  textbackground ( blue ) ;
  clrscr ;
  textcolor ( white ) ;
  gotoxy ( 2,2) ;
  write ( 'r1 : sum of ranks ' ) ;
  gotoxy (2,3) ;
  write ( 'r2 : additive ranking ') ;
  gotoxy ( 40,2) ;
  write ( 'r3 : multiplicative ranking ' ) ;
  gotoxy ( 40,3) ;
  write ( 'r4 : sum of outranking relations ' ) ;
  gotoxy ( 2,5) ;
  textcolor ( red ) ;
  write ( 'hit any key to continue ' ) ;
  read ( kbd , ch ) ;
END ;


BEGIN (* MAIN *)
  pruser1 := namex ;
  numofalternatives := problema.Numofalternatives ;
  numofusers := norm.Numofusers ;
  usersnames := norm.Usersnames ;
  weight := norm.Weight ;
  altvector6[a] := solution.Ahp.Altvector1 ;
  altnames6 := solution.Alternatives ;
  b := 0 ;
  for a := 1 to numofusers do
  begin
    userx :=  norm.Usersnames[a];
    filname1 := concat ( problname,'.',Userx ) ;

    if exist ( filname1 )   then
       b := b + 1 ;
  end ;

  countahp := 0 ;
  countelectre := 0 ;

  if  b < numofusers  then
  begin
    clrscr ;
    writeln ( 'the solutions are not completed ' )
  end ;
  if b = numofusers then
  begin
    for   a := 1 to numofusers  do
    begin
      userx := usersnames[a];
      filname1 := concat ( problname,'.',Userx ) ;
      pruser := filname1 ;
      if  exist ( pruser )  then
      begin
        readsolutionfile ;
        if ( solution.Ahp.Status ) then
        begin
          countahp := countahp + 1 ;
          altvector6[a] := solution.Ahp.Altvector1 ;
          altnames6 := solution.alternatives ;
          Altvector8 := altvector6[a] ;
        end ;
        if ( solution.Electre.Status ) then
        begin
       countelectre := countelectre + 1 ;
       computeindividualvector ;
       individualvector[a] := individualvector1 ;
       altnames6  := solution.Alternatives ;
     end ;
   end ;
end ;

if countahp = numofusers  then
begin
  for a := 1 to numofusers  do
  begin
    altvector8 := altvector6[a] ;
    for  b := 1 to numofalternatives do
         altvector8[b] := altvector8[b] * weight[a] ;
    altvector6[a] := altvector8 ;
  end ;
  window (1,1,25,16 ) ;
  textbackground ( 14 ) ;
  clrscr ;
  window (26,1,50,16 ) ;
  textbackground ( 14 ) ;

  clrscr ;
  window (51,1,80,16 ) ;
  textbackground ( white ) ;
  clrscr ;

  window (1,17,80,23 ) ;
  textbackground ( blue ) ;
  clrscr ;

  window (1,24,80,25 ) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black  ) ;
  gotoxy ( 2,1) ;
  write ( ' step 5 : computation of group decision  ' ) ;
  gotoxy ( 2,2) ;
  write ('all  the solutions have computed with ahp ' ) ;
  window (1,1,25,16 ) ;
  textbackground ( 14 ) ;
  textcolor ( blue ) ;
  clrscr ;
  gotoxy ( 1,2 ) ;
  write ( ' alt. Cardinal rankings ' ) ;
  win1 ;
  win2 ;
  win3 ;
  window1 ;
end ;
```

```
if countelectre = numofusers  then
begin
  for a := 1 to numofusers  do
  begin
    altvector8 := altvector6[a] ;
    for  b := 1 to numofalternatives do
         altvector8[b] := altvector8[b] * weight[a] ;
    altvector6[a] := altvector8 ;
  end ;

  window (1,1,25,16 ) ;
  textbackground ( 14 ) ;
  clrscr ;

  window (26,1,50,16 ) ;
  textbackground ( 14 ) ;
  clrscr ;

  window (51,1,80,16 ) ;
  textbackground ( white ) ;
  clrscr ;

  window (1,17,80,23 ) ;
  textbackground ( blue ) ;

  clrscr ;
  window (1,24,80,25 ) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black  ) ;
  gotoxy ( 2,1) ;
  write ( ' step 5 : computation of group decision  ' ) ;

  gotoxy ( 2,2) ;
  write ('all the solutions have computed with electre');
  window (1,1,25,16 ) ;
  textbackground ( 14 ) ;
  textcolor ( blue ) ;
  clrscr ;
  gotoxy ( 1,2 ) ;
  write ( ' alt. Individual rankings ' ) ;
  win4 ;
  win5 ;
  win6 ;
  window1 ;
end;

count12 := 0 ;
for a := 1 to numofusers do
begin
  userx := usersnames[a];
```

```
filname1 := concat ( problname,'.',Userx ) ;
pruser := filname1 ;
readsolutionfile ;
if solution.Ahp.Status then
begin
  indexm[a] := 'a';
  count12 := count12 + 1 ;
end
else
begin
  if solution.Electre.Status  then
  begin
    indexm[a] := 'e' ;
    count12 := count12 +1 ;
  end
  else
    indexm[a] := 'n' ;
  end ;
end ;
if count12 < numofusers then
begin
  window ( 1,1,80,25) ;
  textcolor ( 14 ) ;
  clrscr ;
  gotoxy ( 2,3) ;
  textcolor ( blue ) ;
  write ('the solutions are not completed ');

  gotoxy ( 2,4) ;
  write ( ' hit any key to return to main menu ' ) ;
  read ( kbd,ch ) ;
  goto telos1 ;
end
else
begin
  for a:= 1 to numofusers do
  begin
    if indexm[a] = 'a' then
    begin
      altvector8 := altvector6[a] ;
      for b := 1 to numofalternatives do
      begin
        suma := 1 ;
        for c := 1 to ( numofalternatives ) do
        begin
          if altvector8[b] < altvector8[c]  then
               suma := suma + 1 ;
        end ;
        ordinal1[b] := suma ;
      end ;
      ordinal[a] := ordinal1 ;
    end
    else
    begin
      individualvector1 := individualvector[a] ;
      for b := 1 to numofalternatives do
      begin
        suma := 1 ;
        for c := 1 to ( numofalternatives ) do
        begin
         if individualvector1[b] <
        individualvector1[c] then
  suma := suma + 1 ;
        end ;
        individualordinal1[b] := suma ;
      end ;
      ordinal[a] :=  individualordinal1 ;
    end ;
  end ;

  window (1,1,25,16 ) ;
  textbackground ( 14 ) ;
  clrscr ;
  window (26,1,50,16 ) ;
  textbackground ( 14 ) ;
  clrscr ;
  window (51,1,80,16 ) ;
  textbackground ( white ) ;
  clrscr ;
  window (1,17,80,23 ) ;
  textbackground ( blue ) ;

  clrscr ;
  window (1,24,80,25 ) ;
  textbackground ( white ) ;
  clrscr ;
  textcolor ( black  ) ;
  gotoxy ( 2,1) ;
  write ('step 5 : computation of group decision  ' ) ;
  gotoxy ( 2,2) ;
  write('the solutions  have computed with electre or
       ahp ');
  window (1,1,25,16 ) ;
  textbackground ( 14 ) ;
  textcolor ( blue ) ;
  clrscr ;

  win7;
  win8 ;
  window1 ;
end ;
window (1,1,80,25) ;
```

```
telos1:
   end ;
END ;
```

INCLUDE FILE DIRLIST1

```
PROCEDURE DIRLIST ;

TYPE

  Char12arr = array [ 1..12 ] of Char;
  String20  = string[ 20 ];
  RegRec = record
       AX,BX,CX,DX,BP,SI,
       DI,DS,ES,Flags : Integer;
  end;

VAR

  Regs : RegRec;
  DTA : array [ 1..43 ] of Byte;
  Mask : Char12arr;
  NamR : String20;
  Error,I : Integer;


BEGIN

  FillChar(DTA,SizeOf(DTA),0);       { Initialize the DTA
                                    buffer}
  FillChar(Mask,SizeOf(Mask),0);     { Initialize the mask }

  FillChar(NamR,SizeOf(NamR),0);    { Initialize the file
                                          name}
  WriteLn;
  WRITELN;
  Regs.AX  := $1A00;            { Function used to set the DTA }
  Regs.DS  := Seg(DTA);         { store the parameter segment in
                                  DS }
  Regs.DX  := Ofs(DTA);         {  offset in DX }
  MSDos(Regs);                  { Set DTA location }
  Error  := 0;
  Mask  := '????????.GN?';       { Use global search }
  Regs.AX  :=  $4E00;             { Get first directory entry }
  Regs.DS  := Seg(Mask);         { Point to the file Mask }
  Regs.DX  := Ofs(Mask);
  Regs.CX  := 22;                { Store the option }
  MSDos(Regs);                   { Execute MSDos call }
  Error  := Regs.AX and $FF;     { Get Error return }
  I := 1;                    { initialize 'I' to  the first
                               element }
  if (Error = 0) then
  repeat
  NamR[I] := Chr(Mem[Seg(DTA):Ofs(DTA)+29+I]);
  I := I + 1;
  until not (NamR[I-1] in [' '..'~']) or (I>20);


  NamR[0] :=  Chr(I-1);        { set string length because
                                assigning }
                              { by element does not
                                set length}
  while (Error = 0) do
  begin
    Error := 0;
    Regs.AX :=  $4F00;           { Function used to get the
                                next }
                                { directory entry }
    Regs.CX := 22;              { Set the file option }
    MSDos( Regs );              { Call MSDos }
    Error := Regs.AX and $FF;   { get the Error return }
    I := 1;
    repeat
      NamR[I] := Chr(Mem[Seg(DTA):Ofs(DTA)+29+I]);
      I := I + 1;
    until not (NamR[I-1] in [' '..'~'] ) or (I > 20);
    NamR[0] := Chr(I-1);
    if (Error = 0) THEN
      WriteLn( '   ', NamR) ;
  end
END ;
```

INCLUDE FILE FILES

```
PROCEDURE OPENFILE ( var  prname : name ) ;

BEGIN
   assign ( problemfile , prname ) ;
   rewrite ( problemfile ) ;
   with  problema  do
   begin
      name1 := prname ;
      numofalternatives := 0 ;
      numofusers := 0 ;
      levels := 0 ;
      fillchar (level1,sizeof(level1),0);
      fillchar (level2,sizeof(level2),0);
      fillchar (level3,sizeof(level3),0);
      fillchar (level4,sizeof(level4),0);
      fillchar (level5,sizeof(level5),0);
      fillchar (level6,sizeof(level6),0);
      fillchar (level7,sizeof(level7),0);
      fillchar (sublevel1,sizeof(sublevel1),0);
      fillchar (sublevel2,sizeof(sublevel2),0);
      fillchar (alternatives,sizeof(alternatives),0);
   end ;
   write ( problemfile , problema ) ;
   close ( problemfile ) ;
END ;

PROCEDURE OPENSOLUTIONFILE ( var  pruser  : name ) ;

BEGIN

   assign ( solutionfile,pruser ) ;
   rewrite ( solutionfile ) ;
   with solutiona  do
   begin
      ahp.Numoftries  := 0 ;
      electre.Numoftries  := 0 ;
      numofalternatives := 0 ;
      numofcriteria := 0 ;
      fillchar(ahp.Altvector1,sizeof(ahp.Altvector1),0);
      username := ' ' ;
      userid   := ' ' ;
      fillchar(alternatives,sizeof(alternatives),0) ;
      fillchar(normvector1,sizeof(normvector1),0) ;
      electre.Status := false ;
      fillchar(electre.Outranking,
               sizeof(electre.Outranking),0) ;
   end ;
   write   ( solutionfile , solutiona ) ;
   close ( solutionfile ) ;
END ;

PROCEDURE OPENNORMFILE ( var  normname : name ) ;

BEGIN
  assign ( normfile ,normname )  ;
  rewrite ( normfile ) ;
   with norma  do
   begin
     numofusers     := 0 ;
     modifytimes    := 0 ;
     lasttime       := 0 ;
     agregation     := false ;
     nai           := false ;
     specialized   := false ;
     broadcasting  := false ;
     modify        := false ;
     fillchar (usersnames,sizeof(usersnames),0);
     fillchar (specindex,sizeof(specindex),0);
     fillchar (usersids,sizeof(usersids),0);
     fillchar (weight ,sizeof(weight),0)      ;
     fillchar (currentname,sizeof(currentname),0);
     fillchar (agregationname,sizeof(agregationname),0);
  end ;
  write   ( normfile ,norma ) ;
  close ( normfile ) ;
END ;

PROCEDURE OPENSPECFILE  ( var  pruser3 : name ) ;

BEGIN
   assign ( specfile,pruser3 ) ;
   rewrite ( specfile ) ;
   with specfile1  do
   begin
      numofusers := 0 ;
      pfactor := 0 ;
      qfactor := 0 ;
      fillchar (vector1,sizeof(vector1),0);
      fillchar (vector2,sizeof(vector2),0);
      fillchar (vector3,sizeof(vector3),0);
      fillchar (vector4,sizeof(vector4),0);
      fillchar (vector5,sizeof(vector5),0);
      fillchar (vector6,sizeof(vector6),0);
      fillchar (vector7,sizeof(vector7),0);
      fillchar (normvector2,sizeof(normvector2),0)  ;
      fillchar (normvector1,sizeof(normvector1),0)  ;
      fillchar (normindex,sizeof(normindex),0)  ;
      fillchar (alternatives,sizeof(alternatives),0)  ;
      fillchar (altmatrix,sizeof(altmatrix),0)  ;
      fillchar (grading,sizeof(grading),0)  ;
      numofcriteria := 0 ;
      numofalternatives := 0 ;
      for a := 1 to 3 do
      begin

        solved[a] := false ;
        finalindex[a] := false ;
        finalindex1[a] := false ;
      end ;
      completed  := false ;
      completedall  := false ;
      ahp.status := false ;
      Fillchar(ahp.altvector1,sizeof(ahp.altvector1),0)  ;
   ahp.numoftries := 0 ;
      electre.status := false ;
      electre.numoftries := 0 ;

Fillchar(electre.outranking,sizeof(electre.outranking),0)  ;
  End ;
   write ( specfile , specfile1 ) ;
   close ( specfile ) ;
END ;
```

INCLUDE FILE UTILITIES

```
PROCEDURE DISKDATA ;

BEGIN
  repeat
    window (1,1,40,12) ;

    textbackground ( blue ) ;
    clrscr ;

    window (41,1,80,12) ;
    textbackground ( blue ) ;
    clrscr ;

    window (1,13,80,23) ;
    textbackground ( 14 ) ;
    clrscr ;

    window ( 1,24,80,25) ;
    textbackground ( white ) ;
    clrscr ;
    textcolor ( black ) ;
    gotoxy ( 2,1) ;
    write ( string128 ) ;
    gotoxy(2,2) ;
    write ( ' files related to the problem ' ) ;

    window (1,1,40,12) ;
    textbackground ( blue ) ;
    textcolor ( white ) ;
    gotoxy ( 2,2) ;
    write ( ' names of problems : ' ) ;
    dirlista ;

    window (41,1,80,12) ;
    textbackground ( blue ) ;
    textcolor ( white ) ;
    gotoxy ( 2,2) ;
    write ( ' names of norm  : ' ) ;
    dirlist ;

    window (1,13,80,23) ;
    textbackground ( 14 ) ;
    textcolor ( black ) ;
    gotoxy ( 3,2) ;
    write('do you want to see a predefined norm (y/n) ? ');
    X1 := 56 ; y1 := 2 ;
    identify ( answer,x1,y1 ) ;
    if answer = 'y' then
    begin
      x1 := 3 ; y1 := 3 ;
      normselection (x1,y1);
      displaynorm ;
    end ;
  until answer = 'n' ;
  clrscr ;
  repeat
    window (1,1,40,12) ;
    textbackground ( blue ) ;
    clrscr ;

    window (41,1,80,12) ;
    textbackground ( blue ) ;
    clrscr ;

    window (1,13,80,23) ;
    textbackground ( 14 ) ;
    clrscr ;

    window ( 1,24,80,25) ;
    textbackground ( white ) ;
    clrscr ;
    textcolor ( black ) ;
    gotoxy ( 2,1) ;
    write ( string128 ) ;
    gotoxy(2,2) ;
    write ( ' files related to the problem ' ) ;

    window (1,1,40,12) ;
    textbackground ( blue ) ;
    textcolor ( white ) ;
    gotoxy ( 2,2) ;
    write ( ' names of problems : ' ) ;
    dirlista ;
    window (41,1,80,12) ;
    textbackground ( blue ) ;
    textcolor ( white ) ;

    gotoxy ( 2,2) ;
    write ( ' names of norm  : ' ) ;
```

```
   dirlist ;
   window (1,13,80,23) ;
   textbackground ( 14 ) ;
   textcolor ( black ) ;
   gotoxy ( 3,2) ;
   write('do you want to see a predefined problem (y/n) ?');
   X1 := 56 ; y1 := 2 ;
   identify ( answer,x1,y1 ) ;
   if answer = 'y' then
   begin
     gotoxy ( 3,3) ;
     repeat
       clreol ;
       write ( ' name of problem ?  ' ) ;
       Read ( answer ) ;
       answer := stupcase ( answer ) ;
       answer := concat ( answer,'.','Def') ;
     until ( exist ( answer ));
     prname := answer ;
     readproblemfile ;

     window (1,1,80,7 ) ;
     textbackground ( blue ) ;

     clrscr ;
     textcolor ( white ) ;
     gotoxy (2,1) ;
     write ( 'name of problem : ', problem.Name1 ) ;
     gotoxy ( 2,2 ) ;
     write ( 'alternatives : ' ) ;
     for a := 1 to problem.Numofalternatives do
     begin
       gotoxy ( 2,a+2 ) ;
       write ( problem.Alternatives[a] ) ;
     end ;
     window ( 1,8,80,25 ) ;
     textbackground ( blue ) ;
     clrscr ;
     gotoxy (2,1) ;
     write ( 'criteria : ' ) ;
     display ( problem )      ;
     gotoxy ( 2,17 ) ;
     textcolor ( red ) ;
     write ( 'hit any key to continue ' ) ;
     read ( kbd ,ch ) ;
     textcolor ( white ) ;
   end ;
 until answer = 'n' ;

END ;
```

```
PROCEDURE DISKSTATUS ;

BEGIN
  diskdata ;
END ;


PROCEDURE READ1 ;
BEGIN
  repeat
    gotoxy ( 2,2) ;
    clreol ;
    write (' the name of the problem  ?   ' ) ;
    Read ( answer ) ;
    specname := concat ( answer,'.Spc') ;
    delete ( answer ,8,length( answer) ) ;
    prname := concat ( answer,'.Def' );
    problname := answer ;
  until exist (prname ) ;
END ;

PROCEDURE READ2 ;
BEGIN
  repeat
    gotoxy ( 2,4) ;

    clreol ;
    write (' the name of the norm ?   ' ) ;
    Read ( answer ) ;
    delete ( answer ,8,length( answer) ) ;
    answer := stupcase ( answer ) ;
    normname  := concat ( answer,'.Gn' );
  until exist (normname ) ;
END ;


PROCEDURE READ3 ;
BEGIN
  gotoxy ( 2,6 );
  write ( ' your name ?    ' ) ;
  Error := false ;
  repeat
    gotoxy ( 16,6) ;
    clreol ;
    read ( namex ) ;
    namex :=  stupcase ( namex ) ;
    for a := 1 to  norm.Numofusers do
    begin
      if namex = norm.Usersnames[a] then
         error := true ;
    end ;
  until ( error ) ;
  b := 0 ;

  repeat
    b := b + 1 ;
  until ( namex = norm.Usersnames[b] ) ;
  str (b,inte) ;
  answer := concat ( '.',Namex ) ;
  pruser := concat ( problname,answer) ;
  pruser3 := concat ( problname,'.spc') ;
END ;


PROCEDURE READ4 ;
BEGIN
  gotoxy ( 2,8 ) ;
  write ( ' your id ?  '  ) ;
  If  ( norm.Usersids[b] = 'x' )    then
  begin
    gotoxy ( 16,8) ;
    read ( idx) ;
    idx := stupcase ( idx ) ;
    norm.Usersids[b] := idx ;
  end
  else
  begin
    repeat
      gotoxy ( 16,8) ;
      clreol;

      read (idx ) ;
      idx := stupcase ( idx ) ;
    until ( idx = norm.Usersids[b] ) ;
  end ;
END ;


PROCEDURE READ5 ;
BEGIN
  gotoxy ( 2,10 ) ;
  write (' the method that you want to use  ?  ' ) ;
  Repeat
    gotoxy ( 49,10) ;
    clreol;
    read (methodx ) ;
    methodx := stupcase ( methodx ) ;
  until (( methodx = 'ahp') or ( methodx = 'electre')
        or ( methodx = 'direct')   ) ;
END ;
```

```
PROCEDURE DATA ;
BEGIN
  window(1,24,80,25);
  textbackground(white) ;
  textcolor ( black ) ;

  gotoxy( 2,1) ;
  clreol ;
  write ( string128 ) ;
  gotoxy(2,2);
  write ( string129 );
  window ( 1,13,80,23) ;
  textbackground ( 14 );
  clrscr ;
  read1 ;
  read2 ;
  readnormfile ;
  read3 ;
  read4 ;
END ;
```

INCLUDE FILE PROCED

```
FUNCTION STUPCASE (st : name ) : name ;
VAR
  I : integer ;
BEGIN
  for I := 1 to length(st) do
       st[i] := upcase(st[i]) ;
  stupcase := st ;
END ;


FUNCTION EXIST (filename : name ) : boolean ;
VAR
  fil : file ;
BEGIN
  assign ( fil , filename ) ;
  {$i-}
  reset ( fil ) ;
  {$i+}
  exist := ( ioresult = 0 ) ;
END ;


PROCEDURE WAIT ;
BEGIN
 gotoxy(50,24); write( 'hit any key to continue ' );
 read(kbd,ch)
END ;
```

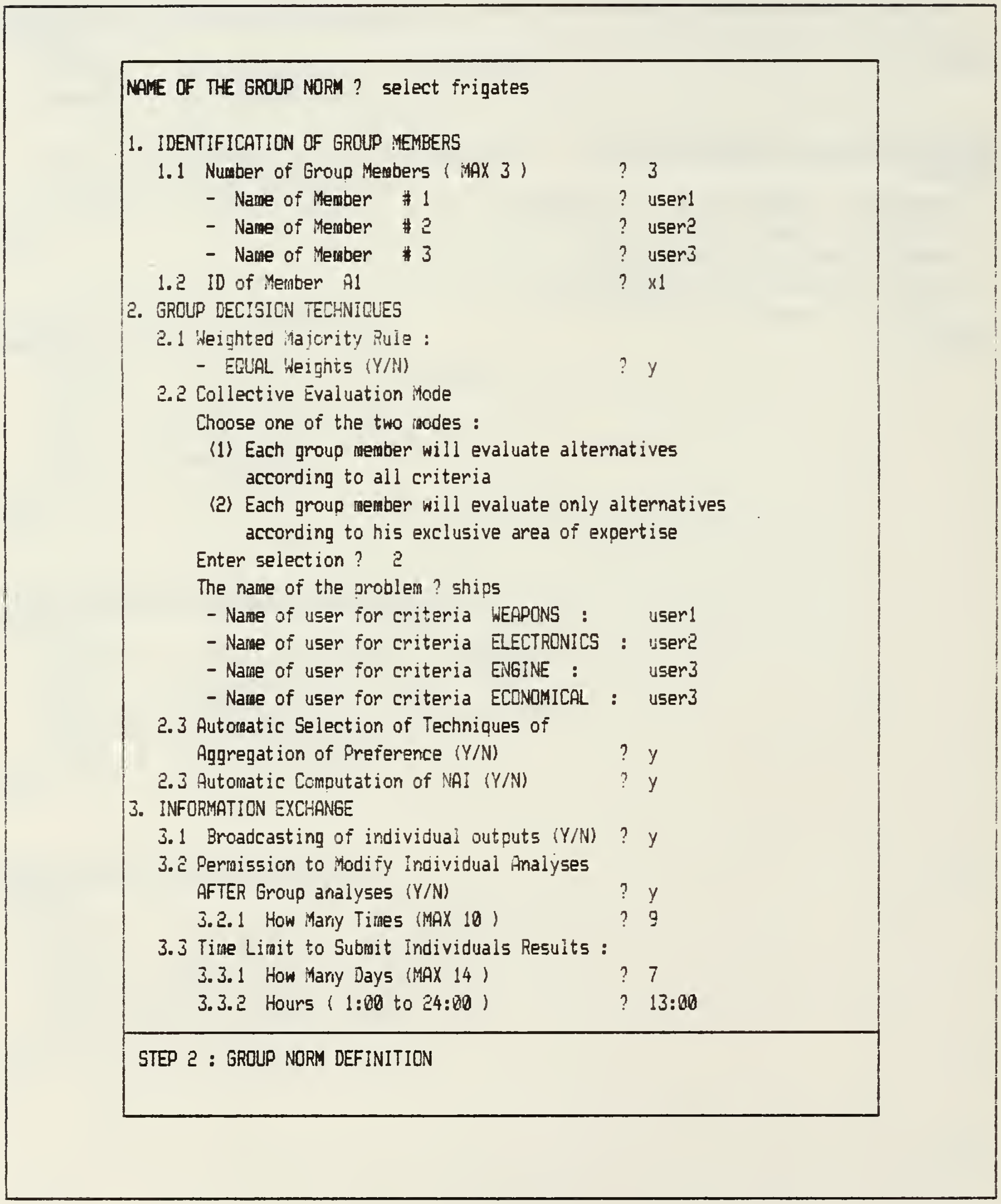
```
PROCEDURE CLEAR1 ( var  problem : case1 ) ;
BEGIN
  for a :=1 to 5 do
      problem.Level1[a] := ' '
END ;

PROCEDURE CLEARSCREEN (var line : integer ) ;
BEGIN
  if line = 19 then
  begin
    gotoxy(1,4) ;
    for e := 1 to 10 do
        delline ;
    line := 9 ;
  end ;
END ;

PROCEDURE CLEAR ( var   matrix2 : level ) ;
BEGIN
  for line := 1 to 5 do
  begin
    for a := 1  to 5 do
        matrix2[line,a] := ' '
  end
END ;

PROCEDURE CONVERT (var answer2 : ask ;var w,d1 : integer ) ;
BEGIN
  if ( answer2[w] <> '1') and  ( answer2[w] <> '2')
     and   ( answer2[w] <> '3') and ( answer2[w] <> '4')
     and   ( answer2[w] <> '5')
then
              d1 := 0  ;
  case    answer2[w]     of
    '1':  d1 := 1 ;
    '2':  d1 := 2 ;
    '3':  d1 := 3 ;
    '4':  d1 := 4 ;
    '5':  d1 := 5 ;
  end ;
END ;

PROCEDURE  IDENTIFY  (  var  answer  :  name  ; var  x1,y1 :
integer ) ; BEGIN
  repeat
    gotoxy(x1,y1);
    clreol ;
    read ( answer ) ;
    answer := stupcase ( answer ) ;
  until ( ( answer = 'y') or ( answer = 'n') ) ;
END ;
```

```
PROCEDURE CHECKNUMBER ( var answer : name ;
                        var x1,y1,limit : integer ;
                        var  count3 : real  ) ;
BEGIN
  repeat
    gotoxy ( x1,y1) ;
    clreol ;

    read  ( answer ) ;
    val ( answer,count3,code1) ;
  until((code1 = 0)and(count3 <= limit) and (count3 >= 0)) ;
END ;


PROCEDURE SORT1 ( var normvector1 : vectorg ;
                  var normvector2 : vectorn ;
                  var numofcriteria : integer ) ;
BEGIN
  repeat
    count := 0 ;
    for a := 1 to numofcriteria  do
    begin
      if normvector2[a] < normvector2[a+1]  then
      begin
        exchange2[a] := normvector2[a] ;
        normvector2[a] := normvector2[a+1] ;
        normvector2[a+1] := exchange2[a] ;
        exchange1[a] := normvector1[a] ;
        normvector1[a] := normvector1[a+1] ;
        normvector1[a+1] := exchange1[a] ;
        count := count + 1 ;
      end ;
    end;
  until  count = 0 ;
END ;


PROCEDURE WRITENORMFILE ;
BEGIN
  assign ( normfile ,normname ) ;
  reset ( normfile ) ;
  norma := norm ;
  write ( normfile ,norma ) ;
  close ( normfile ) ;
END ;


PROCEDURE WRITEPROBLEMFILE ;
BEGIN
  assign ( problemfile , prname ) ;
  reset ( problemfile ) ;
  problema := problem ;
  write ( problemfile, problema ) ;
  close ( problemfile ) ;
END ;


PROCEDURE READPROBLEMFILE  ;
BEGIN
  assign ( problemfile , prname ) ;
  reset ( problemfile ) ;

  read ( problemfile , problema ) ;
  problem := problema ;
  close ( problemfile ) ;
END ;


PROCEDURE READNORMFILE ;
BEGIN
  assign ( normfile , normname ) ;
  reset ( normfile ) ;
  read ( normfile , norma ) ;
  norm  := norma ;
  close ( normfile  ) ;
END ;


PROCEDURE READSOLUTIONFILE ;
BEGIN
  assign ( solutionfile , pruser ) ;
  reset ( solutionfile ) ;
  read ( solutionfile , solutiona ) ;
  solution := solutiona ;
  close ( solutionfile  ) ;
END ;


PROCEDURE READSPECFILE ;
BEGIN
  assign ( specfile , pruser3 ) ;
  reset ( specfile ) ;
  read ( specfile , specfile1 ) ;
  specfile2 := specfile1  ;
  close ( specfile ) ;
END ;
```

```
PROCEDURE WRITESOLUTIONFILE ;
BEGIN
  assign ( solutionfile , pruser ) ;
  reset ( solutionfile ) ;

  solutiona := solution ;
  write (solutionfile,solutiona ) ;
  close ( solutionfile  ) ;
END ;


PROCEDURE WRITESPECFILE ;
BEGIN
  assign ( specfile , pruser3 ) ;
  reset ( specfile ) ;
  specfile1 := specfile2  ;
  write (specfile,specfile1 ) ;
  close ( specfile  ) ;
END ;
```

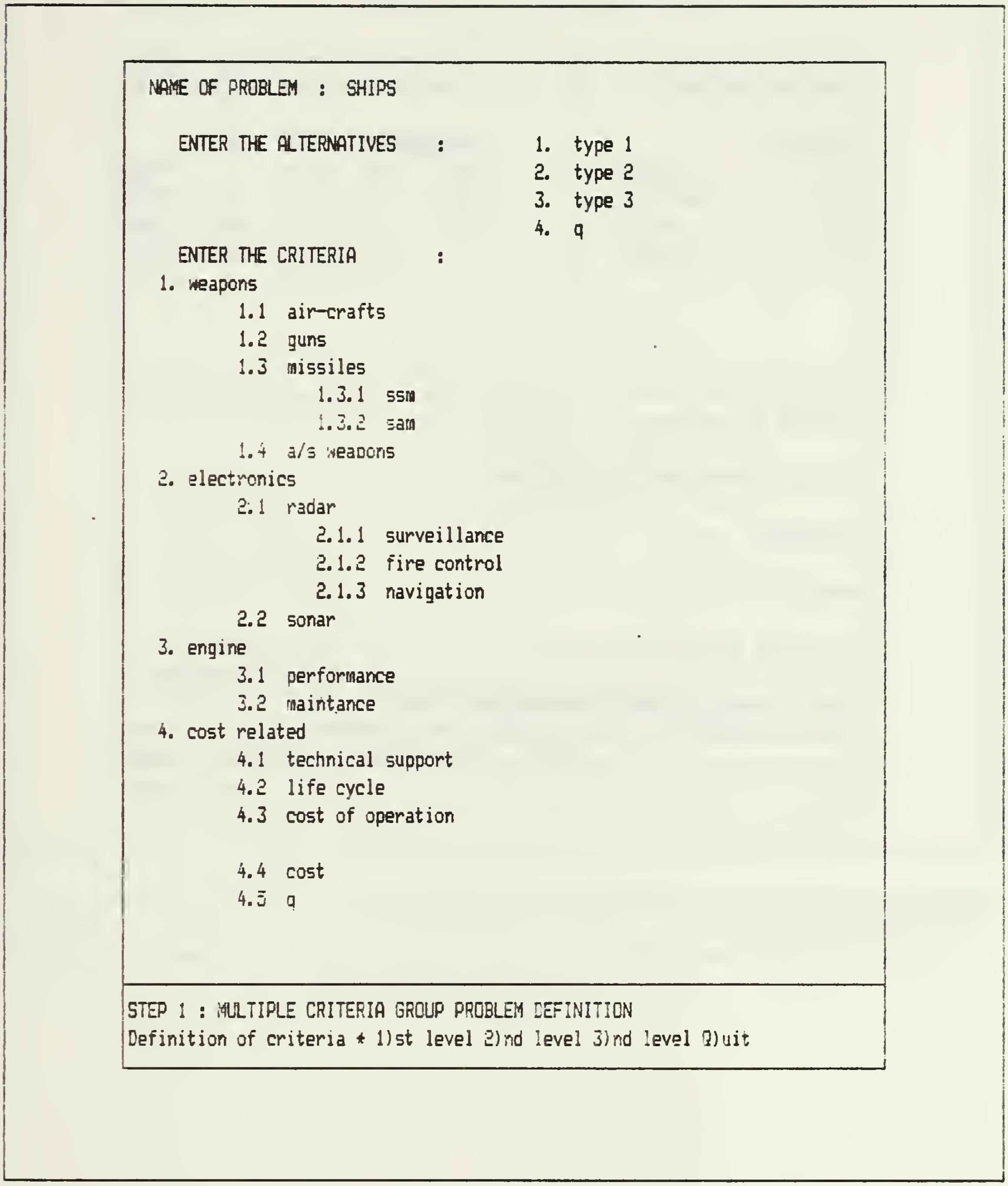
APPENDIX B

FIGURES OF SCENARIO 1



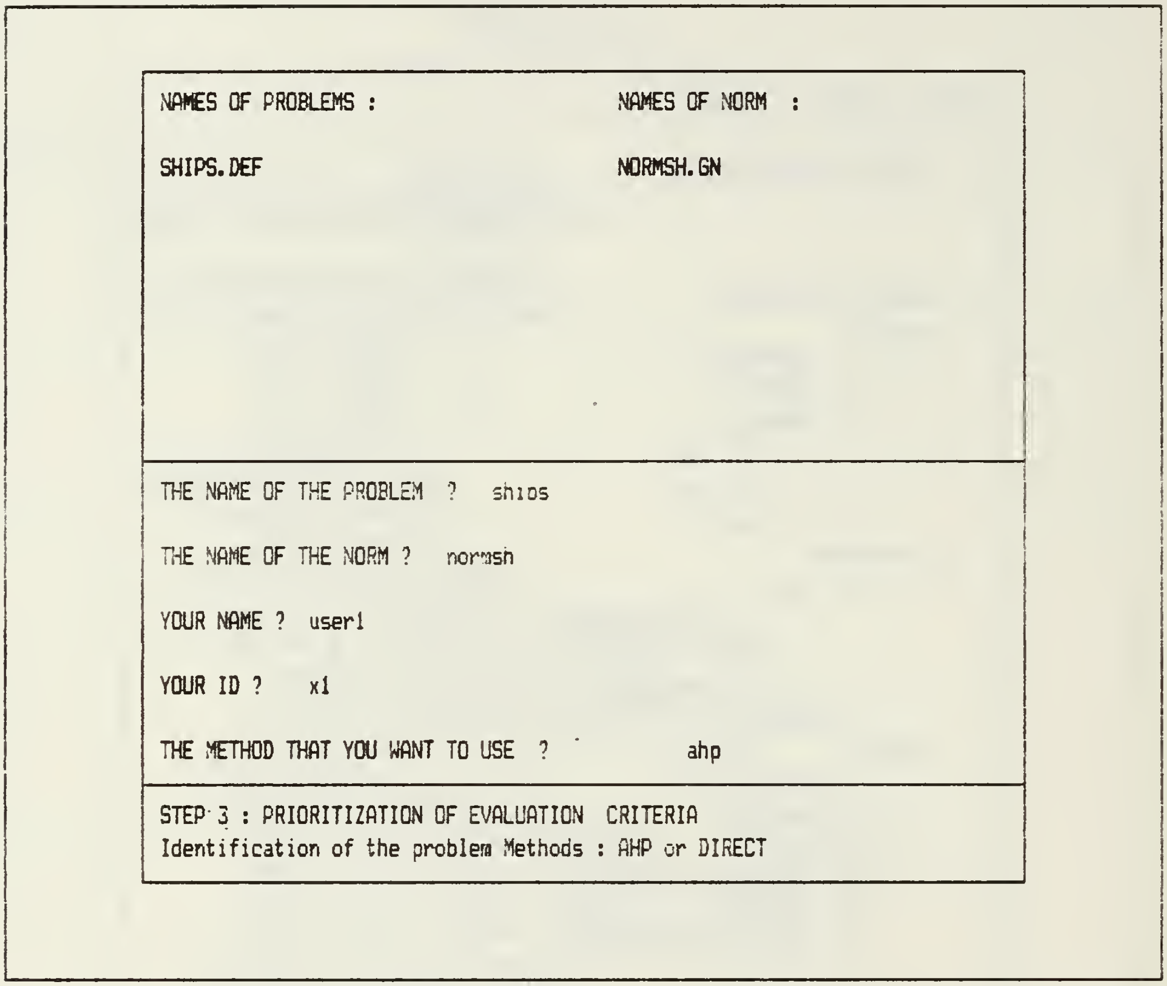
```
NAME OF THE GROUP NORM ?  select frigates

1. IDENTIFICATION OF GROUP MEMBERS
   1.1  Number of Group Members ( MAX 3 )         ?  3
        -  Name of Member   # 1                   ?  user1
        -  Name of Member   # 2                   ?  user2
        -  Name of Member   # 3                   ?  user3
   1.2  ID of Member  A1                          ?  x1
2. GROUP DECISION TECHNIQUES
   2.1 Weighted Majority Rule :
       -  EQUAL Weights (Y/N)                     ?  y
   2.2 Collective Evaluation Mode
       Choose one of the two modes :
         (1) Each group member will evaluate alternatives
             according to all criteria
         (2) Each group member will evaluate only alternatives
             according to his exclusive area of expertise
       Enter selection ?   2
       The name of the problem ? ships
        - Name of user for criteria  WEAPONS  :      user1
        - Name of user for criteria  ELECTRONICS  :  user2
        - Name of user for criteria  ENGINE  :       user3
        - Name of user for criteria  ECONOMICAL  :   user3
   2.3 Automatic Selection of Techniques of
       Aggregation of Preference (Y/N)            ?  y
   2.3 Automatic Computation of NAI (Y/N)         ?  y
3. INFORMATION EXCHANGE
   3.1  Broadcasting of individual outputs (Y/N)  ?  y
   3.2 Permission to Modify Individual Analyses
       AFTER Group analyses (Y/N)                 ?  y
       3.2.1  How Many Times (MAX 10 )            ?  9
   3.3 Time Limit to Submit Individuals Results :
       3.3.1  How Many Days (MAX 14 )             ?  7
       3.3.2  Hours ( 1:00 to 24:00 )             ?  13:00

 STEP 2 : GROUP NORM DEFINITION
```

Figure 4. Group Norm Definition



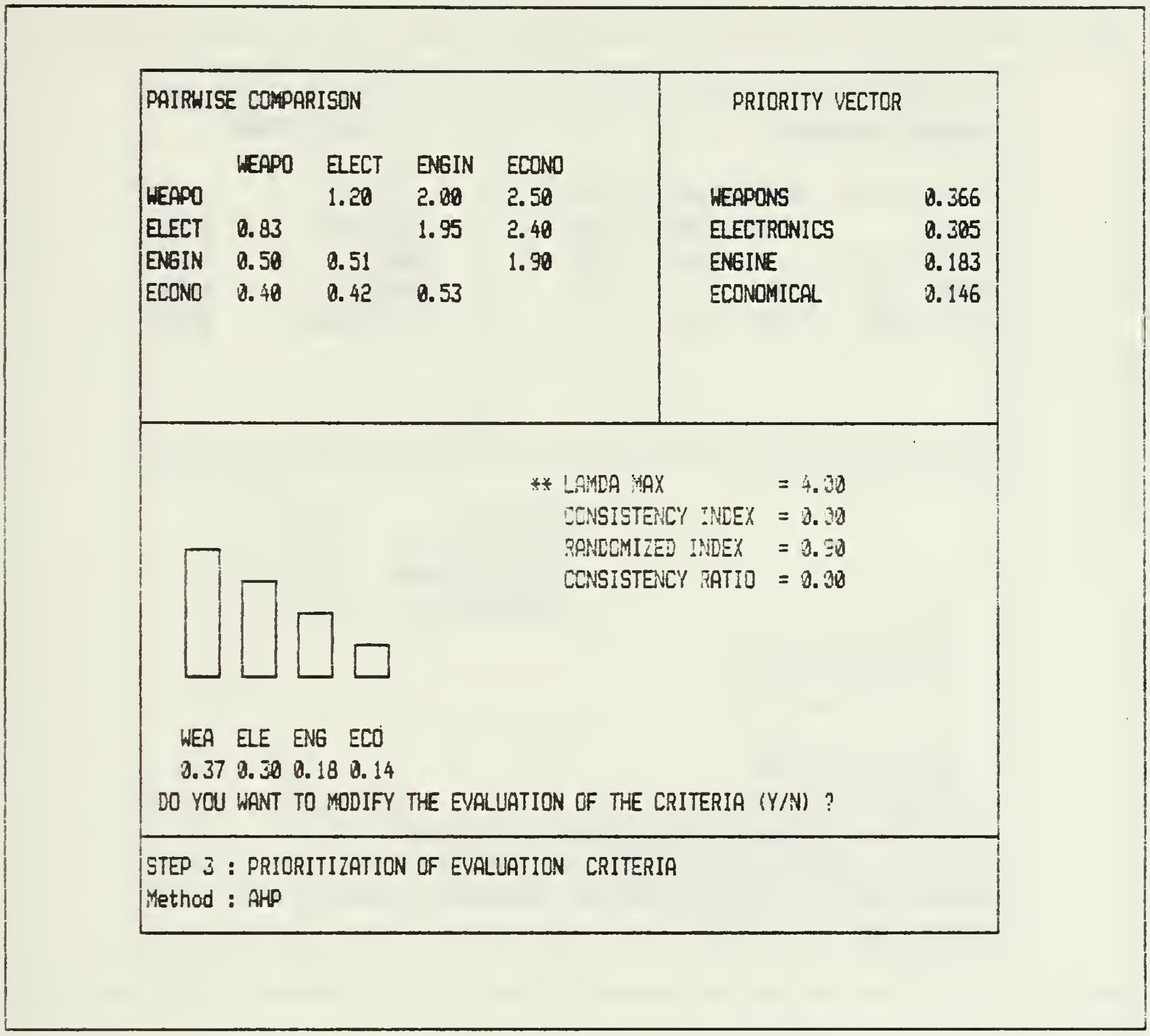
```
 NAME OF PROBLEM  :  SHIPS

   ENTER THE ALTERNATIVES     :        1.  type 1
                                       2.  type 2
                                       3.  type 3
                                       4.  q
   ENTER THE CRITERIA         :
  1. weapons
         1.1  air-crafts
         1.2  guns
         1.3  missiles
                 1.3.1  ssm
                 1.3.2  sam
         1.4  a/s weapons
  2. electronics
         2.1  radar
                 2.1.1  surveillance
                 2.1.2  fire control
                 2.1.3  navigation
         2.2  sonar
  3. engine
         3.1  performance
         3.2  maintance
  4. cost related
         4.1  technical support
         4.2  life cycle
         4.3  cost of operation

         4.4  cost
         4.5  q

STEP 1 : MULTIPLE CRITERIA GROUP PROBLEM DEFINITION
Definition of criteria * 1)st level 2)nd level 3)nd level Q)uit
```

Figure 5. Step 1 Group Problem Definition



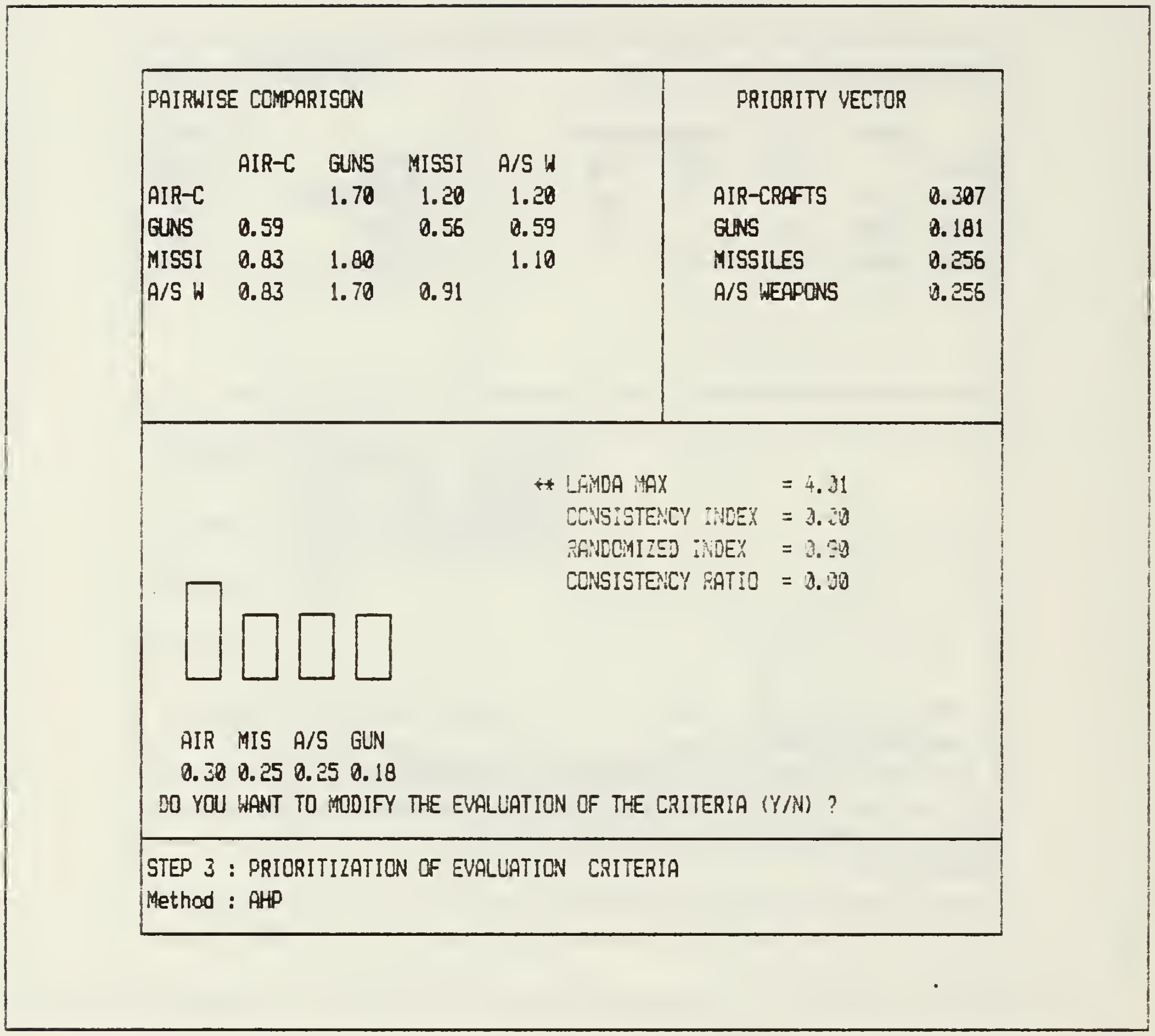
```
NAMES OF PROBLEMS :                       NAMES OF NORM  :

SHIPS.DEF                                 NORMSH.GN

THE NAME OF THE PROBLEM  ?   shios

THE NAME OF THE NORM ?   normsh

YOUR NAME ?  user1

YOUR ID ?    x1

THE METHOD THAT YOU WANT TO USE  ?           ahp

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Identification of the problem Methods : AHP or DIRECT
```

Figure 6 User 1 / Problem Initiation



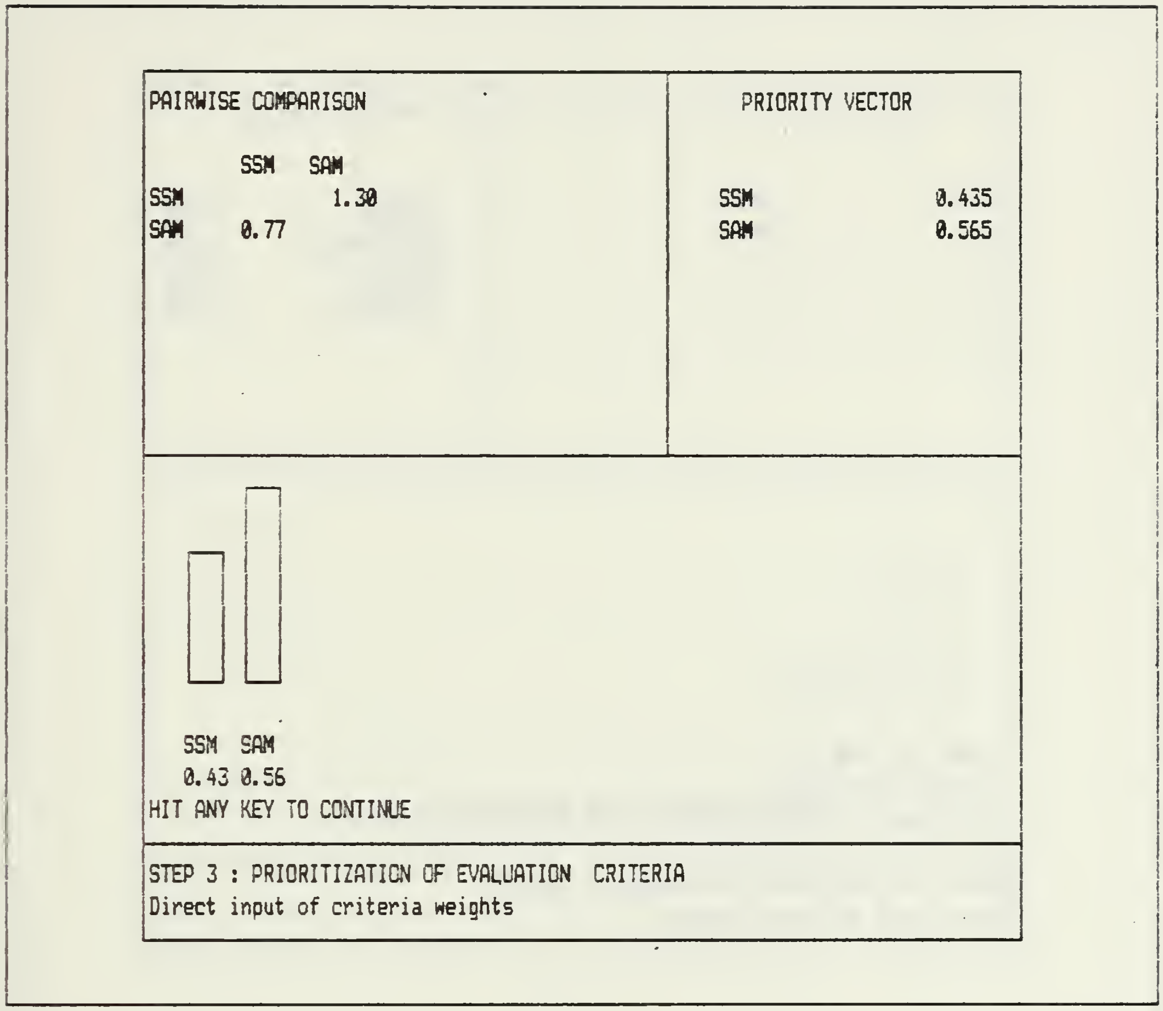
```
PAIRWISE COMPARISON                                 PRIORITY VECTOR

        WEAPO   ELECT   ENGIN   ECONO
WEAPO           1.20    2.00    2.50           WEAPONS           0.366
ELECT   0.83            1.95    2.40           ELECTRONICS       0.305
ENGIN   0.50    0.51            1.90           ENGINE            0.183
ECONO   0.40    0.42    0.53                   ECONOMICAL        0.146

                                    ** LAMDA MAX          = 4.00
                                       CONSISTENCY INDEX  = 0.00
                                       RANDOMIZED INDEX   = 0.90
                                       CONSISTENCY RATIO  = 0.00

   WEA  ELE  ENG  ECO
   0.37 0.30 0.18 0.14
 DO YOU WANT TO MODIFY THE EVALUATION OF THE CRITERIA (Y/N) ?

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Method : AHP
```

Figure 7. User 1 / Prioritization of Evaluation Criteria at the First Level



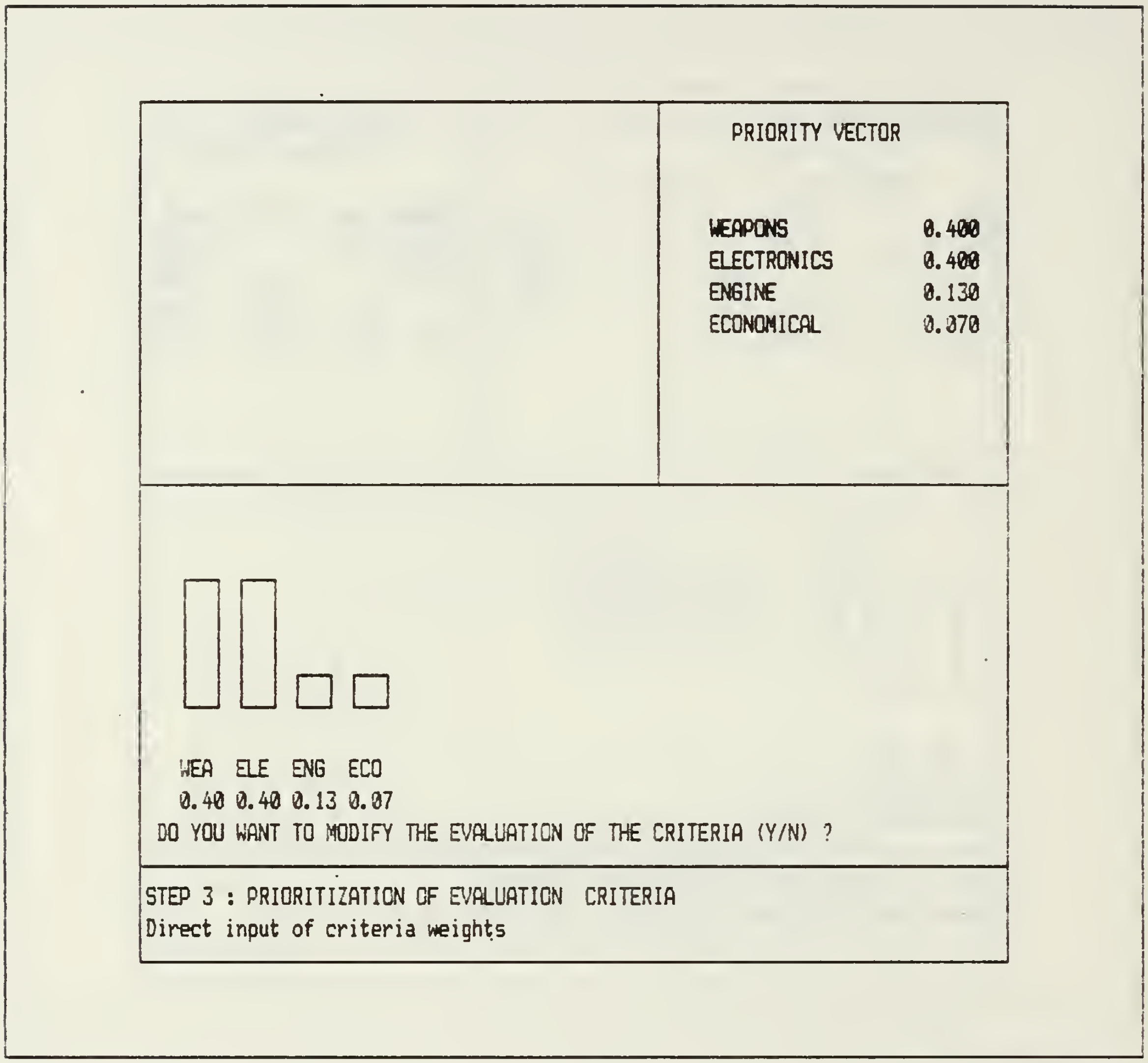
```
PAIRWISE COMPARISON                                  PRIORITY VECTOR

        AIR-C   GUNS   MISSI   A/S W
AIR-C           1.70    1.20    1.20               AIR-CRAFTS        0.307
GUNS    0.59            0.56    0.59               GUNS              0.181
MISSI   0.83    1.80            1.10               MISSILES          0.256
A/S W   0.83    1.70    0.91                       A/S WEAPONS       0.256


                                  ←* LAMDA MAX          = 4.01
                                     CONSISTENCY INDEX  = 0.00
                                     RANDOMIZED INDEX   = 0.90
                                     CONSISTENCY RATIO  = 0.00




   AIR  MIS  A/S  GUN
   0.30 0.25 0.25 0.18
 DO YOU WANT TO MODIFY THE EVALUATION OF THE CRITERIA (Y/N) ?

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Method : AHP
```

Figure 8. User 1 / Prioritization of Evaluation Criteria at Level 2 For Criteria 1.1 to 1.4



```
PAIRWISE COMPARISON                        PRIORITY VECTOR

       SSM   SAM
SSM           1.30                        SSM               0.435
SAM    0.77                               SAM               0.565

   SSM  SAM
   0.43 0.56
HIT ANY KEY TO CONTINUE

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Direct input of criteria weights
```

Figure 9. User 1 / Prioritization of Evaluation Criteria at Level 3 for Criteria 1.3.1 and 1.3.2

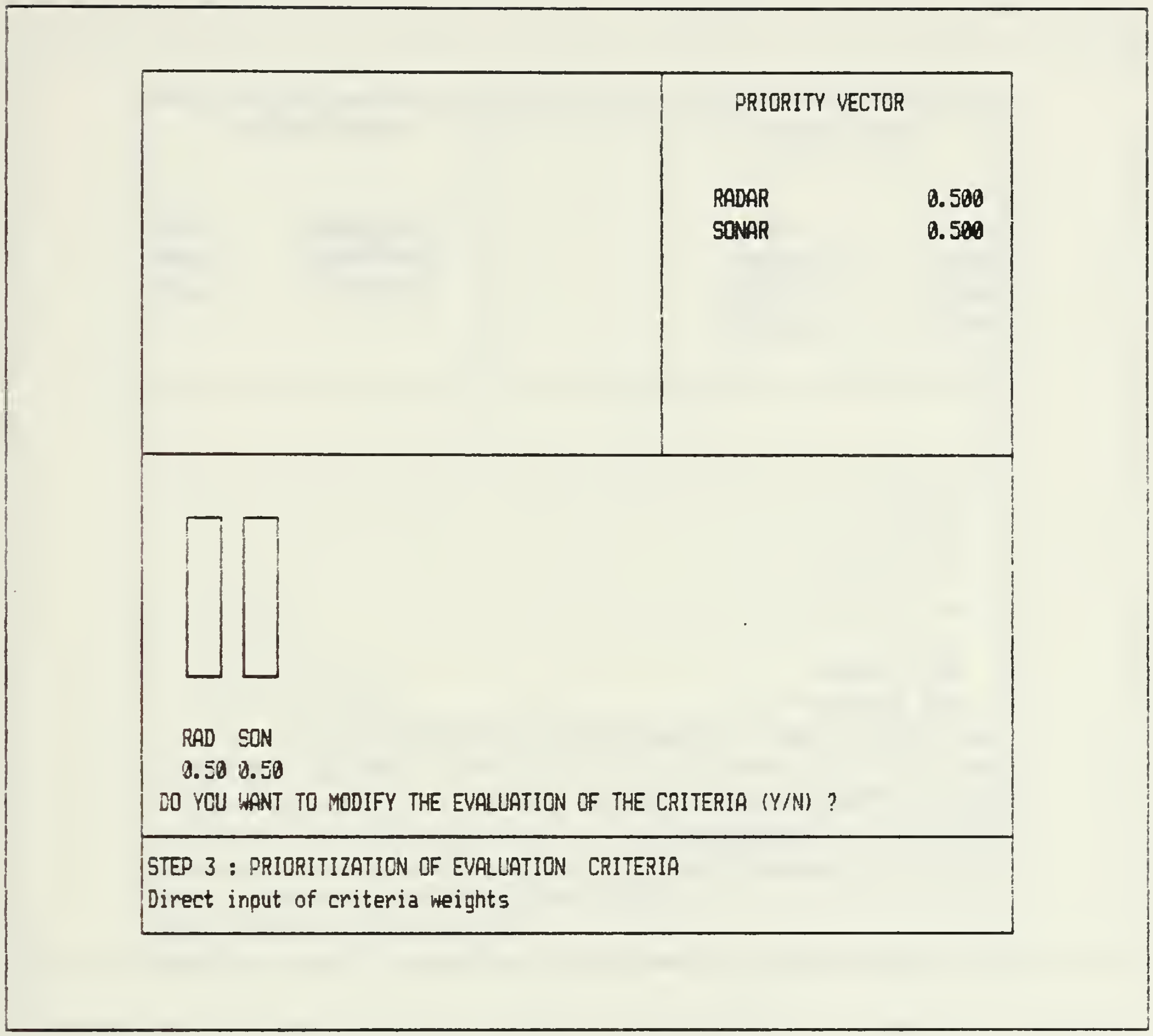


```
PRIORITY VECTOR

WEAPONS          0.400
ELECTRONICS      0.400
ENGINE           0.130
ECONOMICAL       0.070
```

```
WEA  ELE  ENG  ECO
0.40 0.40 0.13 0.07
DO YOU WANT TO MODIFY THE EVALUATION OF THE CRITERIA (Y/N) ?
```

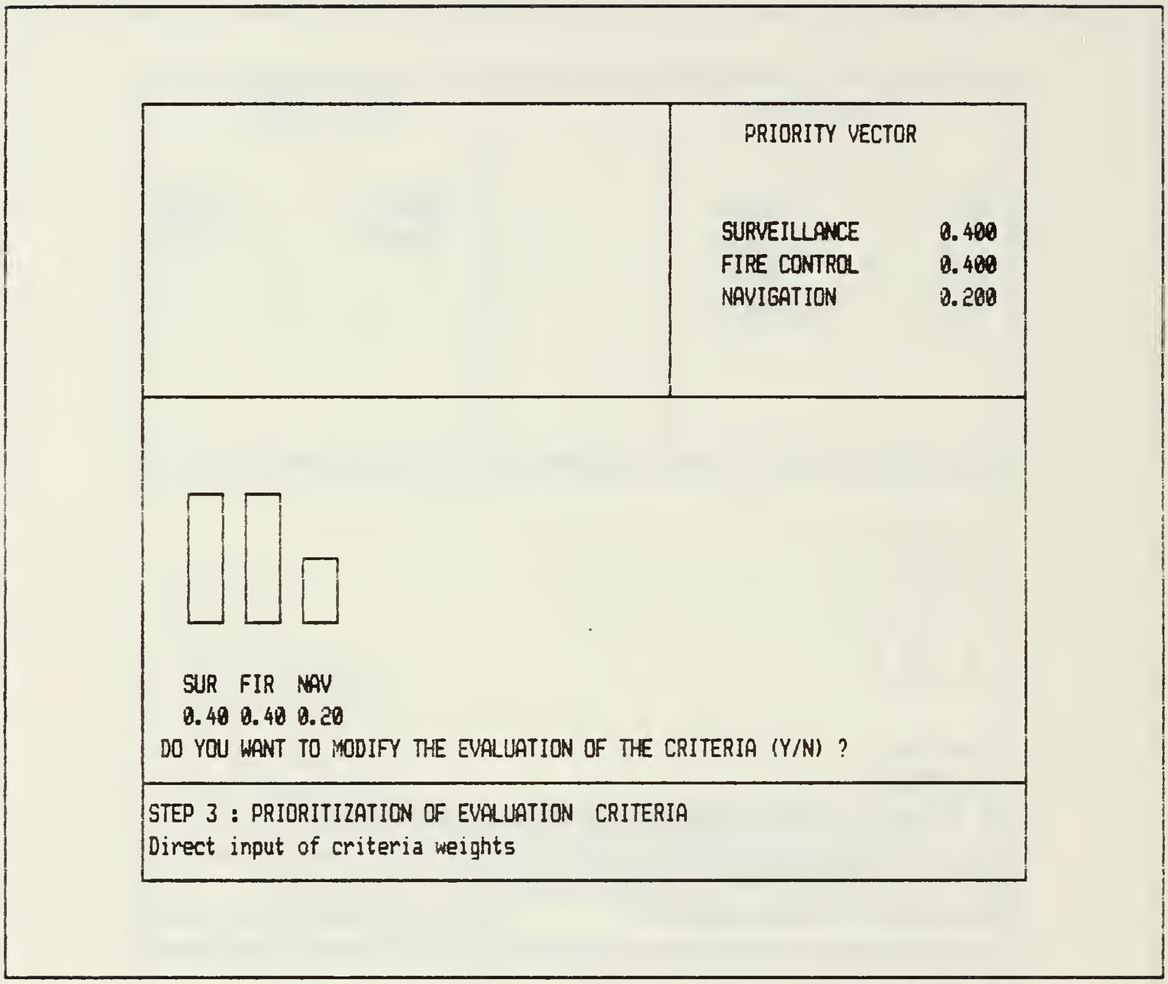
```
STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Direct input of criteria weights
```

Figure 10. User 2 / Prioritization of Evaluation Criteria for Level 1



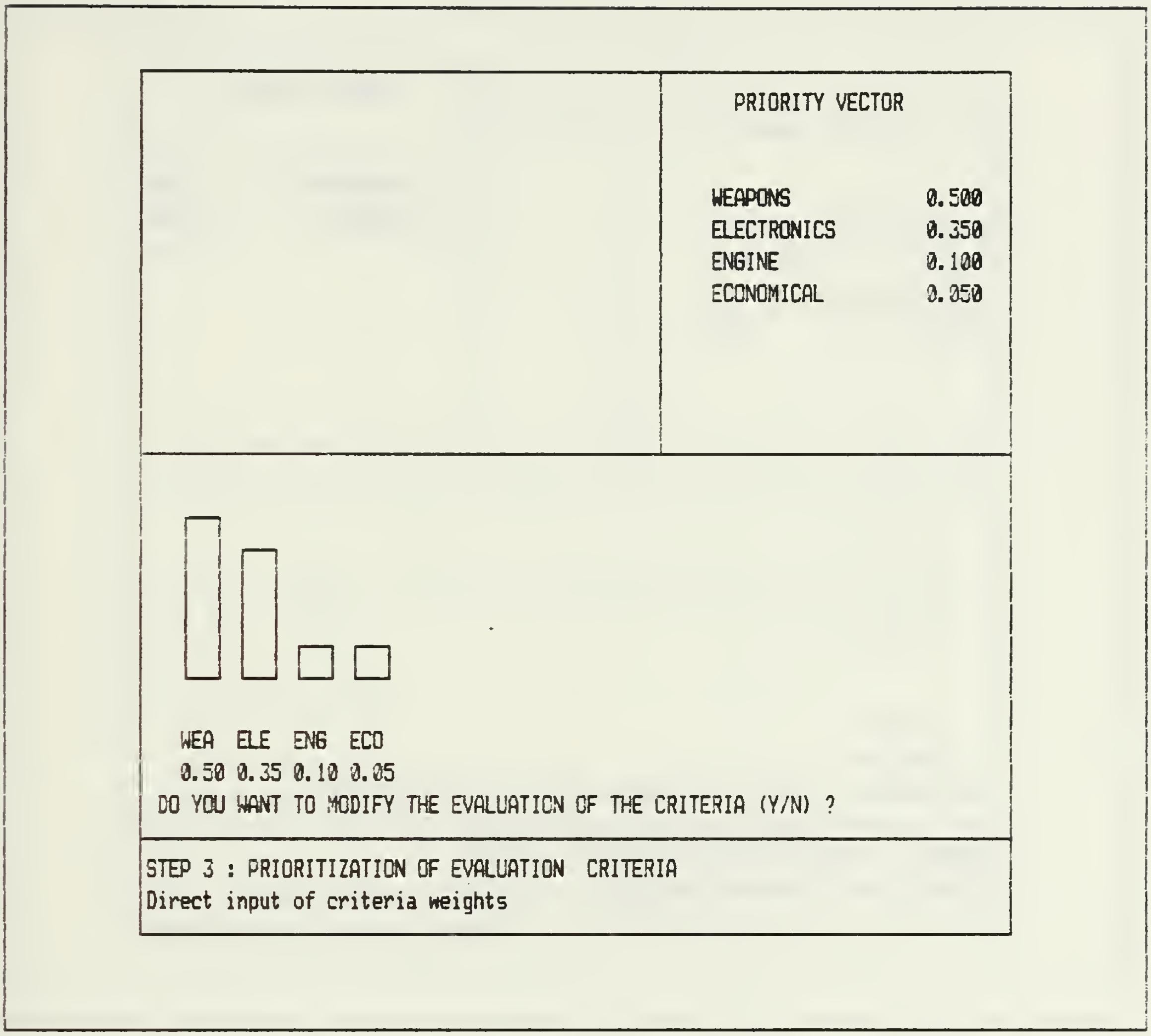
```
PRIORITY VECTOR

RADAR          0.500
SONAR          0.500

DO YOU WANT TO MODIFY THE EVALUATION OF THE CRITERIA (Y/N) ?

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Direct input of criteria weights
```

Figure 11. User 2 / Prioritization of Evaluation Criteria at Level 2 for Criteria 2.1 and 2.2



```
                                   PRIORITY VECTOR

                                 SURVEILLANCE       0.400
                                 FIRE CONTROL       0.400
                                 NAVIGATION         0.200

  SUR  FIR  NAV
  0.40 0.40 0.20
 DO YOU WANT TO MODIFY THE EVALUATION OF THE CRITERIA (Y/N) ?

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Direct input of criteria weights
```

Figure 12. User 2 / Prioritization of Evaluation Criteria at Level 3 for Criteria 2.1.1 to 2.1.3

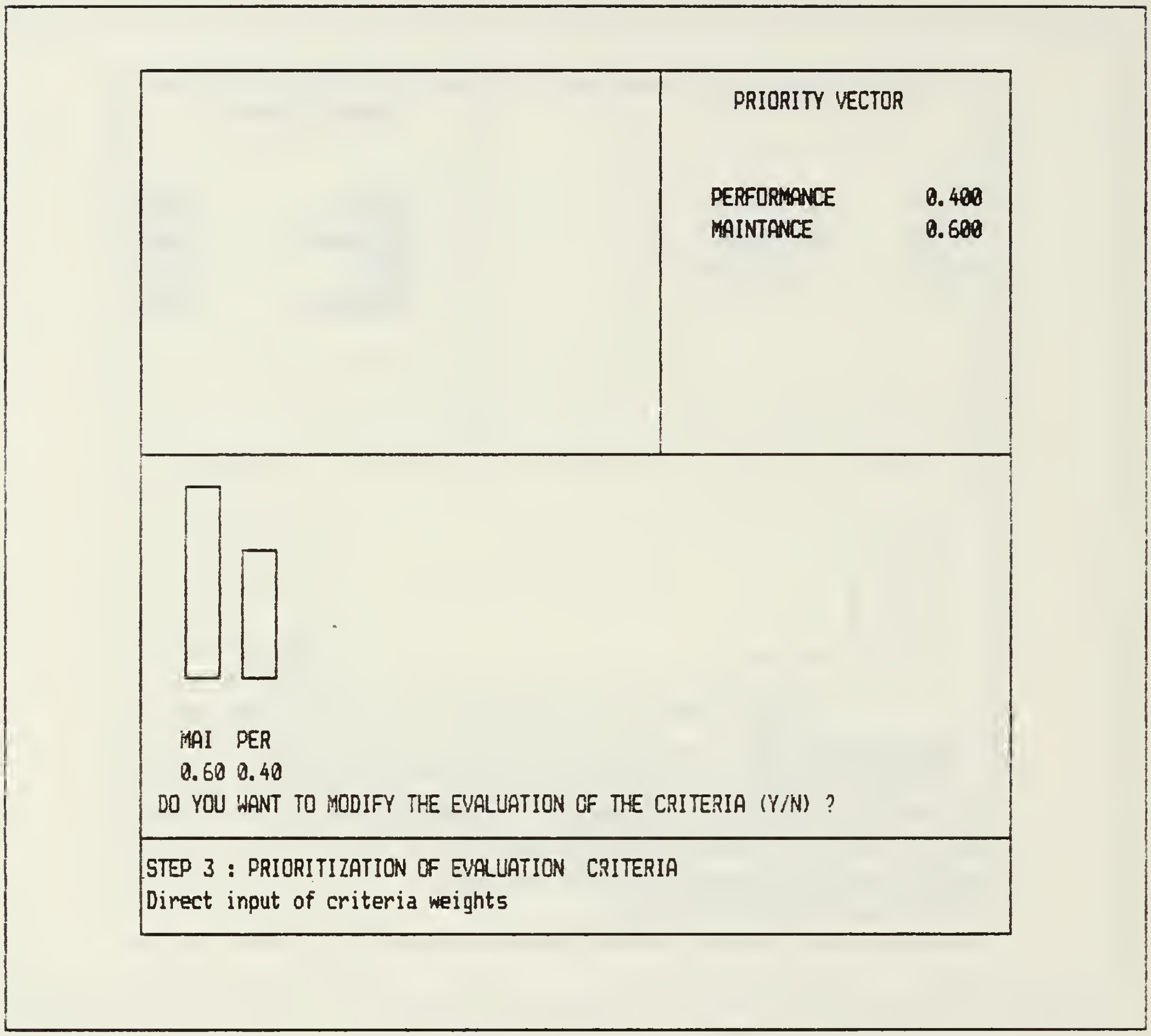


```
PRIORITY VECTOR

WEAPONS          0.500
ELECTRONICS      0.350
ENGINE           0.100
ECONOMICAL       0.050
```

```
WEA  ELE  ENG  ECO
0.50 0.35 0.10 0.05
DO YOU WANT TO MODIFY THE EVALUATION OF THE CRITERIA (Y/N) ?
```

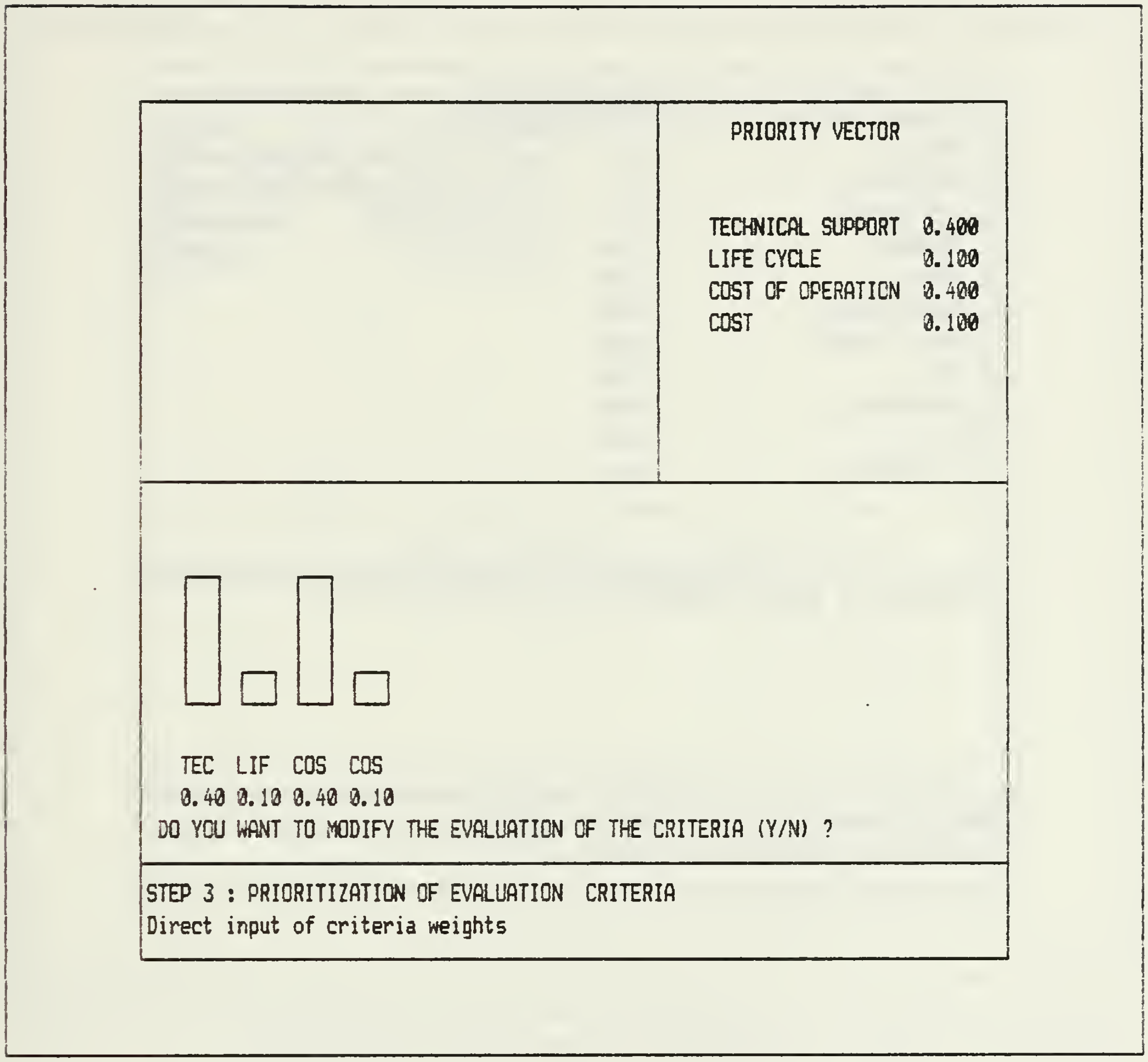
```
STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Direct input of criteria weights
```

Figure 13. User 3 / Prioritization of Evaluation Criteria at Level 1



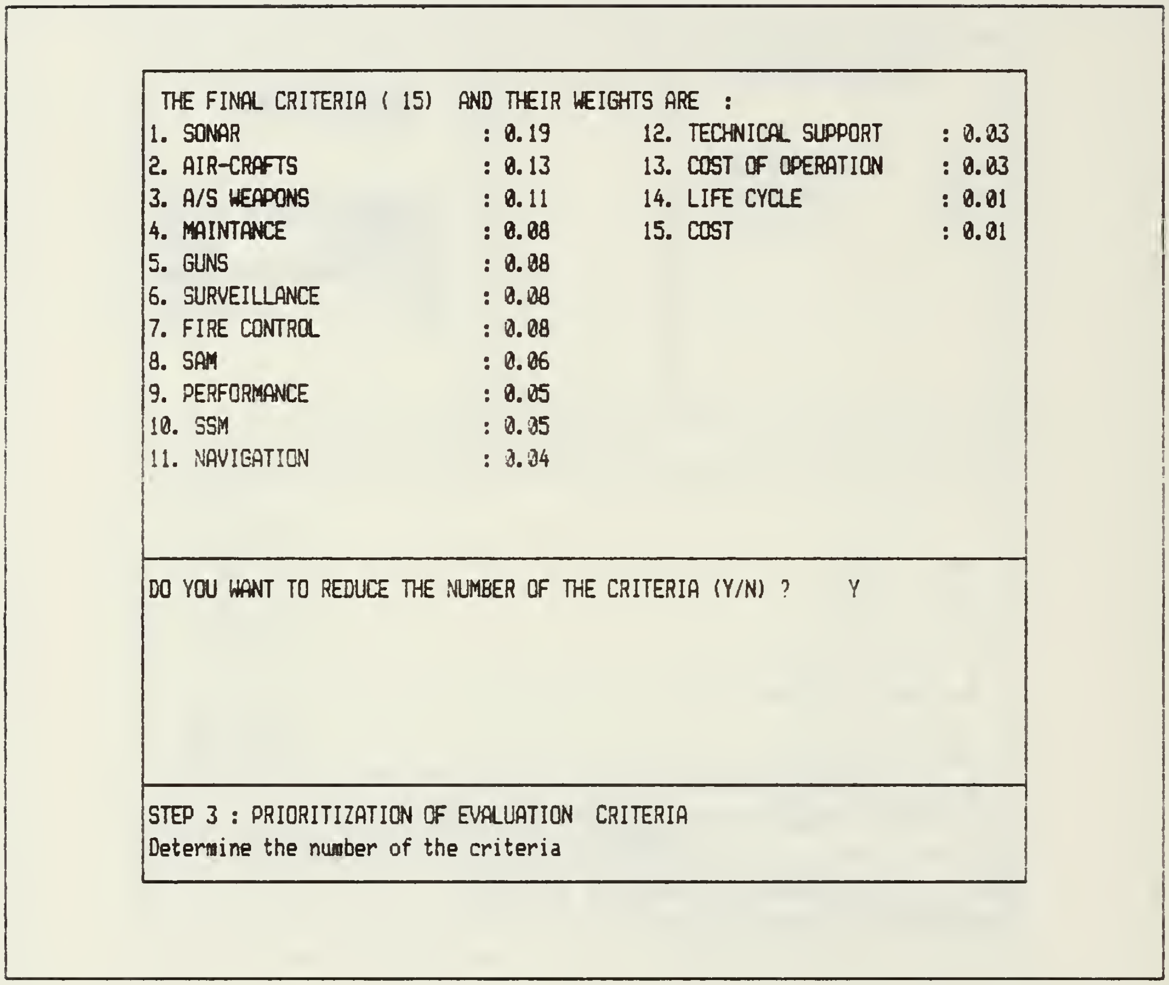
```
PRIORITY VECTOR

PERFORMANCE        0.400
MAINTANCE          0.600

MAI  PER
0.60 0.40
DO YOU WANT TO MODIFY THE EVALUATION OF THE CRITERIA (Y/N) ?

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Direct input of criteria weights
```

Figure 14. User 3 / Prioritization of Evaluation Criteria at Level 2 for Criteria 3.1 and 3.2



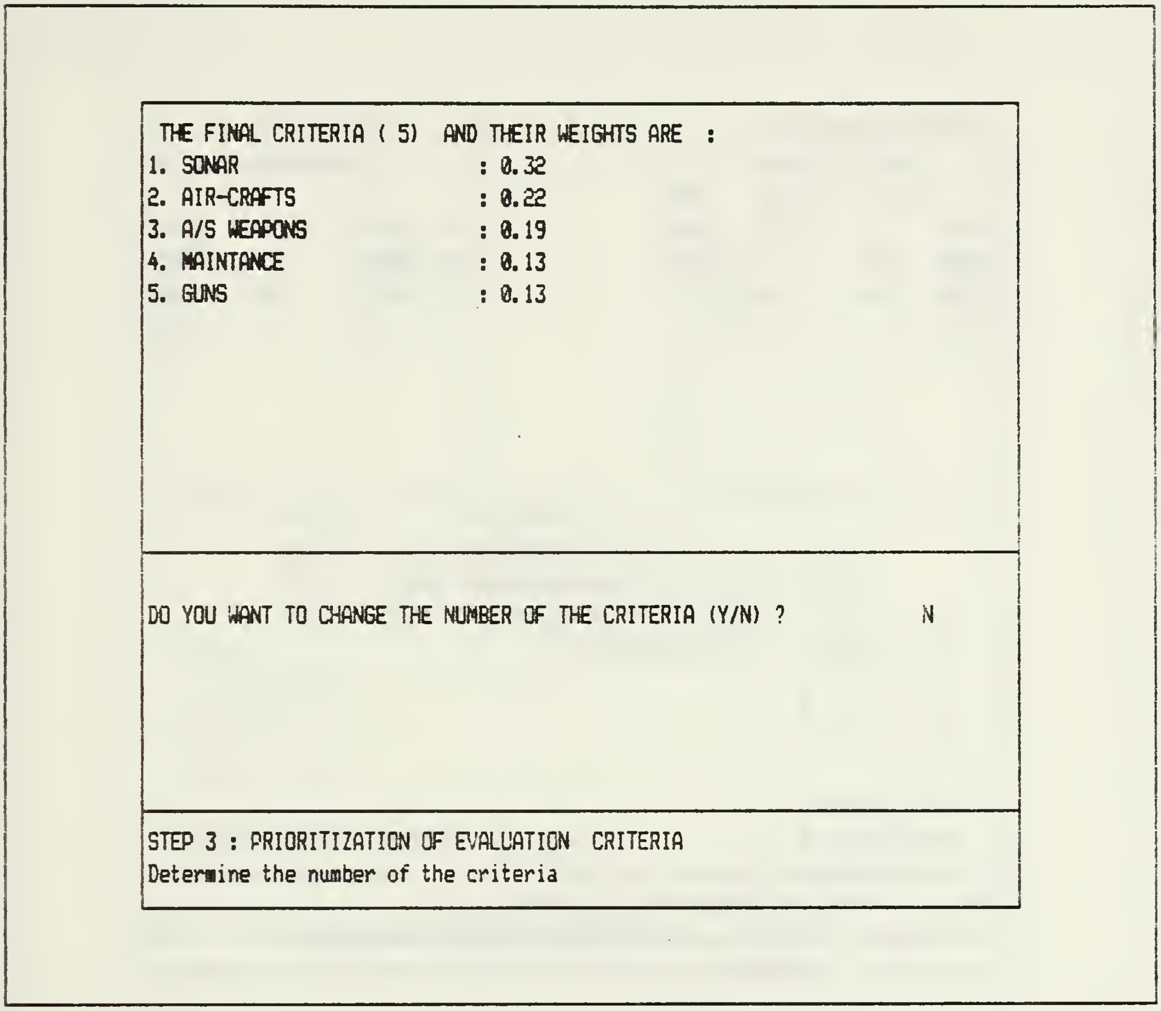
```
                                    PRIORITY VECTOR


                                  TECHNICAL SUPPORT  0.400
                                  LIFE CYCLE         0.100
                                  COST OF OPERATION  0.400
                                  COST               0.100

  TEC  LIF  COS  COS
  0.40 0.10 0.40 0.10
 DO YOU WANT TO MODIFY THE EVALUATION OF THE CRITERIA (Y/N) ?

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Direct input of criteria weights
```

Figure 15. User 3 / Prioritization of Evaluation Criteria at Level 2 for Criteria 4.1 To 4.4



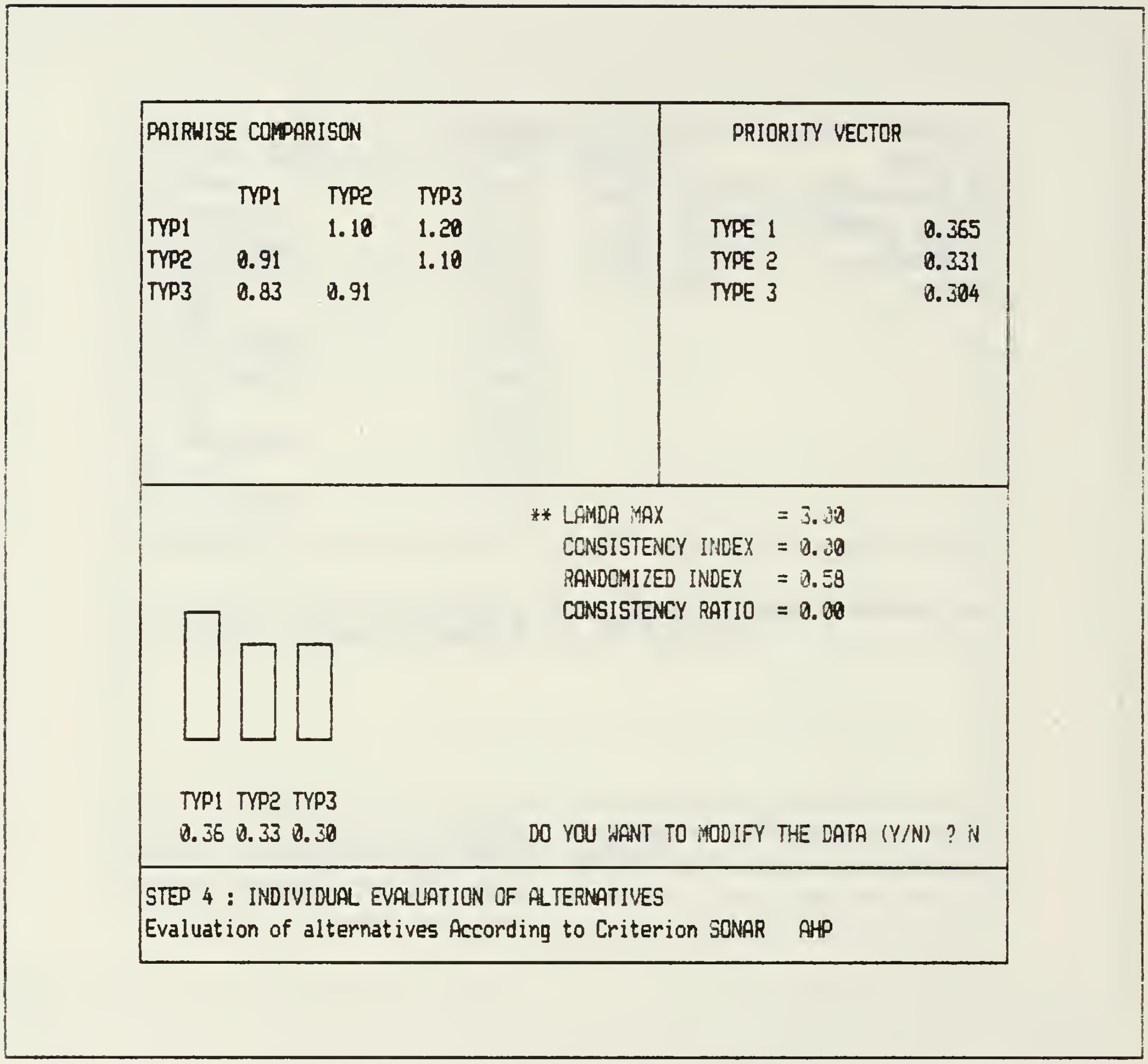
```
 THE FINAL CRITERIA ( 15)  AND THEIR WEIGHTS ARE  :
1. SONAR                      : 0.19       12. TECHNICAL SUPPORT     : 0.03
2. AIR-CRAFTS                 : 0.13       13. COST OF OPERATION     : 0.03
3. A/S WEAPONS                : 0.11       14. LIFE CYCLE            : 0.01
4. MAINTANCE                  : 0.08       15. COST                  : 0.01
5. GUNS                       : 0.08
6. SURVEILLANCE               : 0.08
7. FIRE CONTROL               : 0.08
8. SAM                        : 0.06
9. PERFORMANCE                : 0.05
10. SSM                       : 0.05
11. NAVIGATION                : 0.04

DO YOU WANT TO REDUCE THE NUMBER OF THE CRITERIA (Y/N) ?     Y

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Determine the number of the criteria
```

Figure 16. Final Weights of Evaluation Criteria



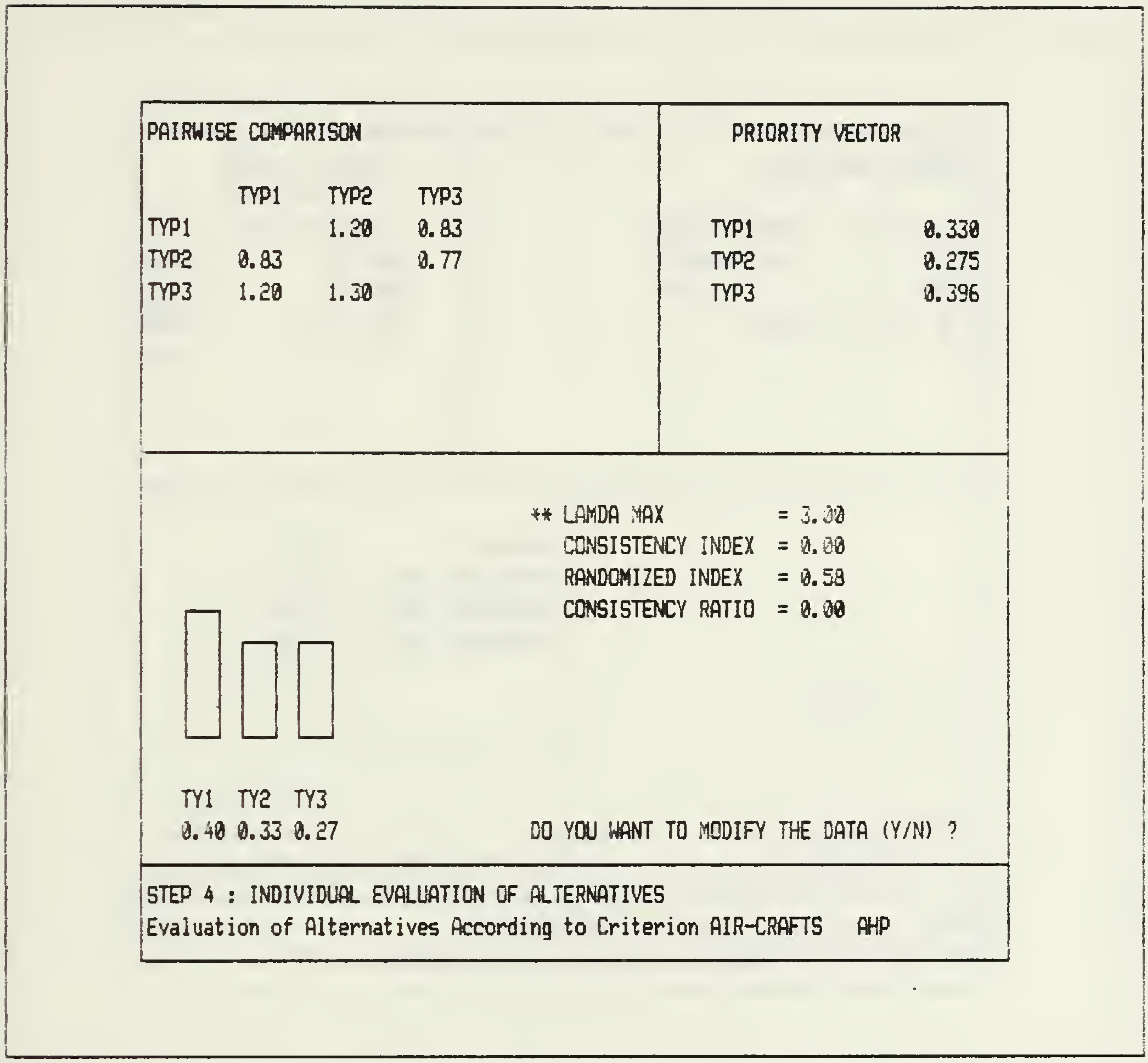
```
 THE FINAL CRITERIA ( 5)  AND THEIR WEIGHTS ARE  :
1. SONAR                 : 0.32
2. AIR-CRAFTS            : 0.22
3. A/S WEAPONS           : 0.19
4. MAINTANCE             : 0.13
5. GUNS                  : 0.13

DO YOU WANT TO CHANGE THE NUMBER OF THE CRITERIA (Y/N) ?          N

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Determine the number of the criteria
```

Figure 17. The Reduced Set of Criteria



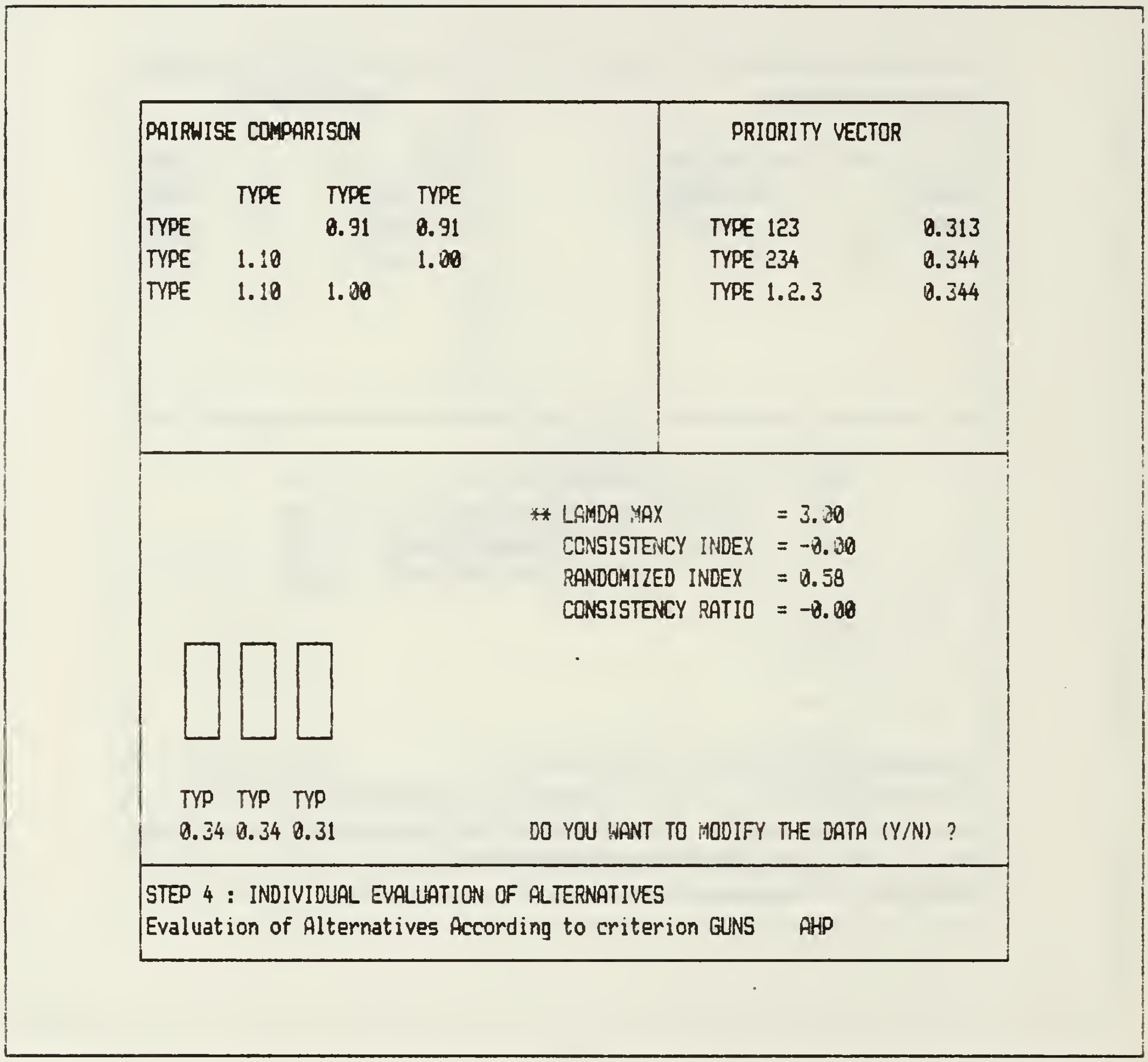
```
PAIRWISE COMPARISON                                  PRIORITY VECTOR

        TYP1     TYP2     TYP3
TYP1             1.10     1.20                  TYPE 1            0.365
TYP2    0.91              1.10                  TYPE 2            0.331
TYP3    0.83     0.91                           TYPE 3            0.304

                                 ** LAMDA MAX           = 3.00
                                    CONSISTENCY INDEX   = 0.00
                                    RANDOMIZED INDEX    = 0.58
                                    CONSISTENCY RATIO   = 0.00

   TYP1 TYP2 TYP3
   0.36 0.33 0.30                DO YOU WANT TO MODIFY THE DATA (Y/N) ? N

STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Evaluation of alternatives According to Criterion SONAR   AHP
```

Figure 18. User 2 / Evaluation of the Alternatives According to Criteria Sonar (AHP)



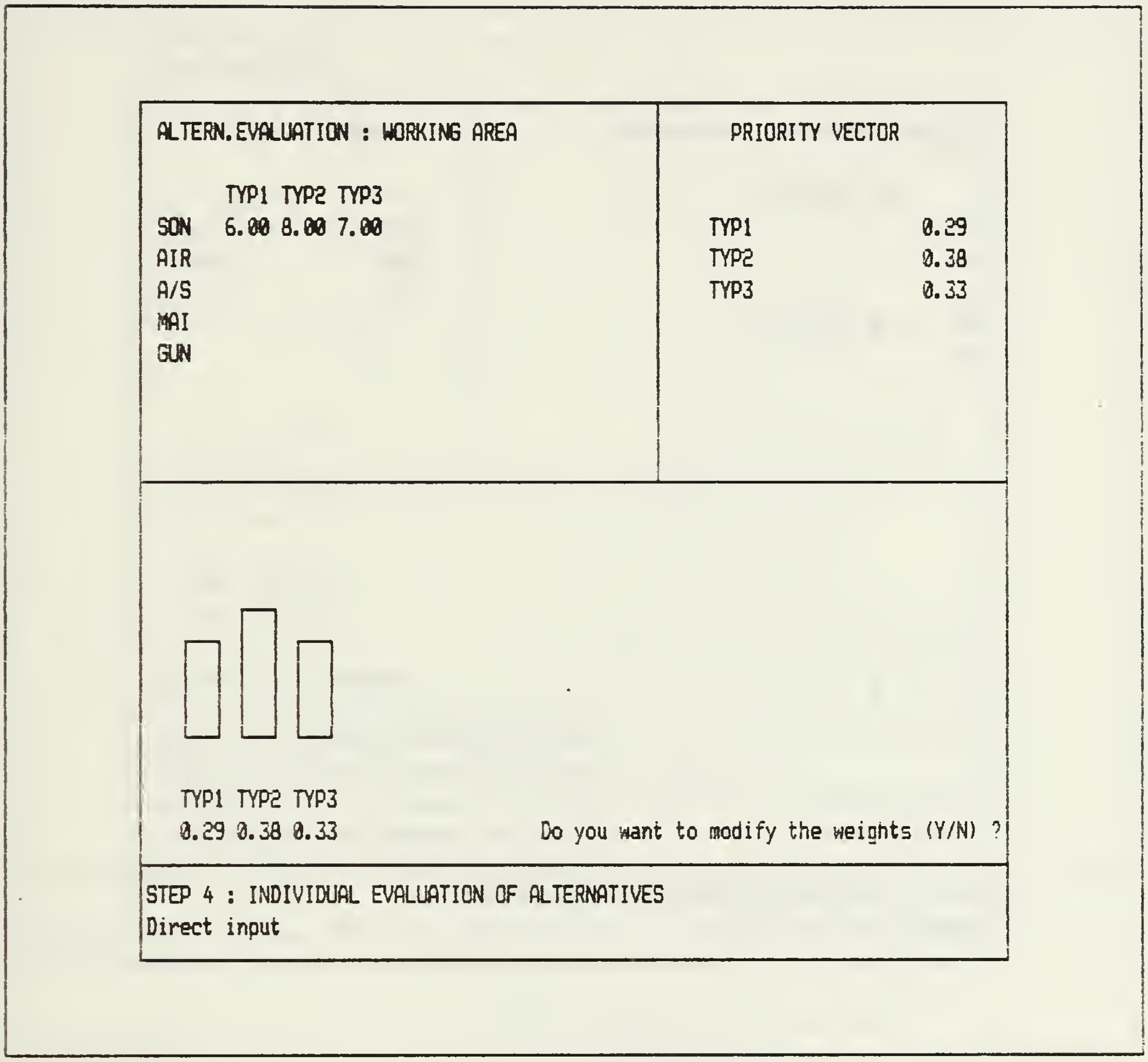
```
PAIRWISE COMPARISON                              PRIORITY VECTOR

        TYP1     TYP2     TYP3
TYP1             1.20     0.83                 TYP1                0.330
TYP2    0.83              0.77                 TYP2                0.275
TYP3    1.20     1.30                          TYP3                0.396


                                 ** LAMDA MAX          = 3.00
                                    CONSISTENCY INDEX  = 0.00
                                    RANDOMIZED INDEX   = 0.58
                                    CONSISTENCY RATIO  = 0.00



  TY1  TY2  TY3
 0.40 0.33 0.27                  DO YOU WANT TO MODIFY THE DATA (Y/N) ?

STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Evaluation of Alternatives According to Criterion AIR-CRAFTS   AHP
```

Figure 19. User 1 / Evaluation of Alternatives According to Criterion Air-Crafts (AHP)



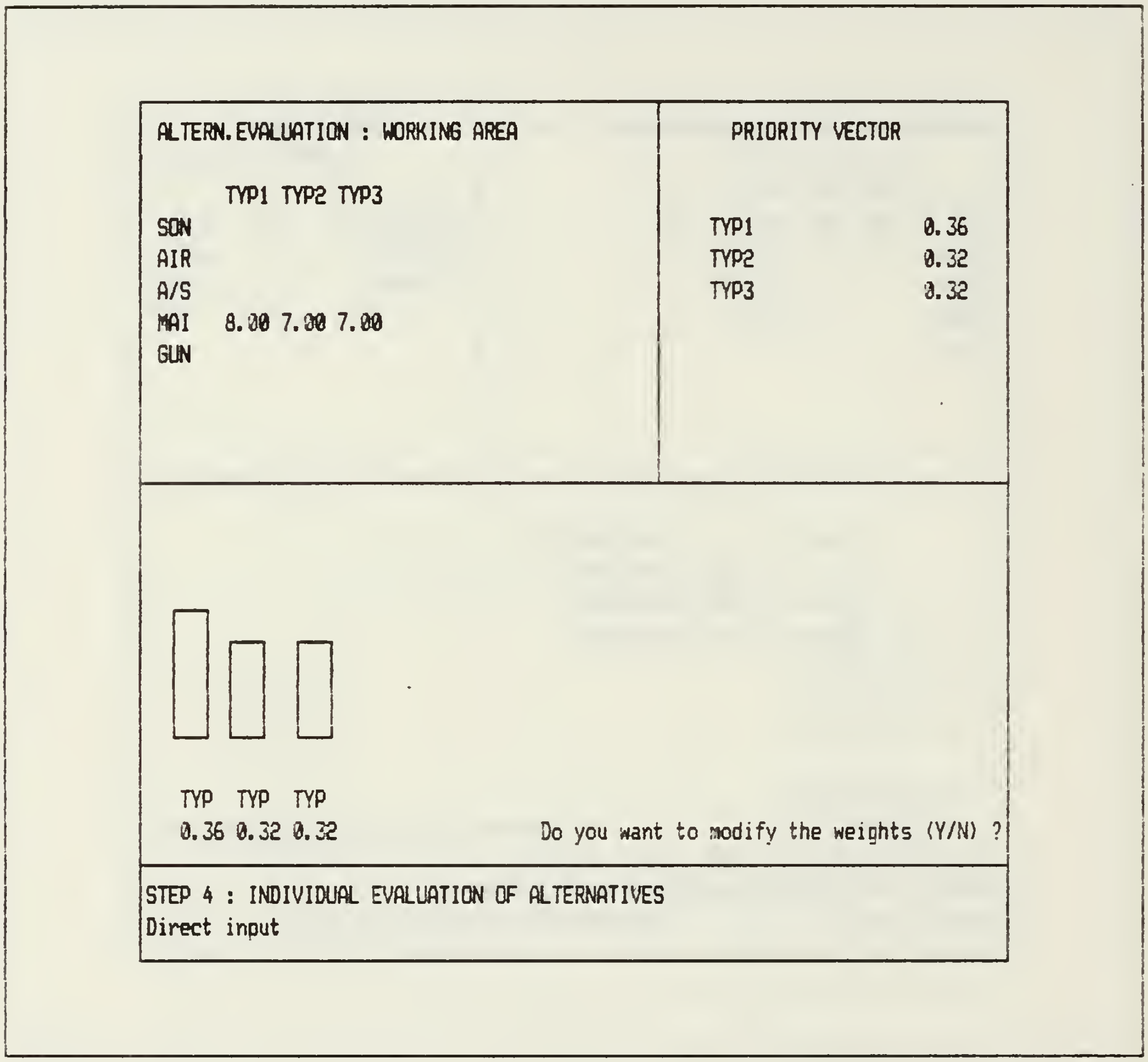
```
PAIRWISE COMPARISON                         PRIORITY VECTOR

        TYPE    TYPE    TYPE
TYPE            0.91    0.91              TYPE 123          0.313
TYPE    1.10            1.00              TYPE 234          0.344
TYPE    1.10    1.00                      TYPE 1.2.3        0.344


                                 ** LAMDA MAX          = 3.00
                                    CONSISTENCY INDEX  = -0.00
                                    RANDOMIZED INDEX   = 0.58
                                    CONSISTENCY RATIO  = -0.00


   TYP  TYP  TYP
   0.34 0.34 0.31                DO YOU WANT TO MODIFY THE DATA (Y/N) ?

STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Evaluation of Alternatives According to criterion GUNS    AHP
```

Figure 20. User 1 / Evaluation of Alternatives According to Criteria Guns (AHP)



```
ALTERN.EVALUATION : WORKING AREA              PRIORITY VECTOR

     TYP1 TYP2 TYP3
SON  6.00 8.00 7.00                       TYP1              0.29
AIR                                       TYP2              0.38
A/S                                       TYP3              0.33
MAI
GUN

TYP1 TYP2 TYP3
0.29 0.38 0.33          Do you want to modify the weights (Y/N) ?

STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Direct input
```

Figure 21. User 2 / Evaluation of alternatives According to Criterion Sonar (DIRECT)

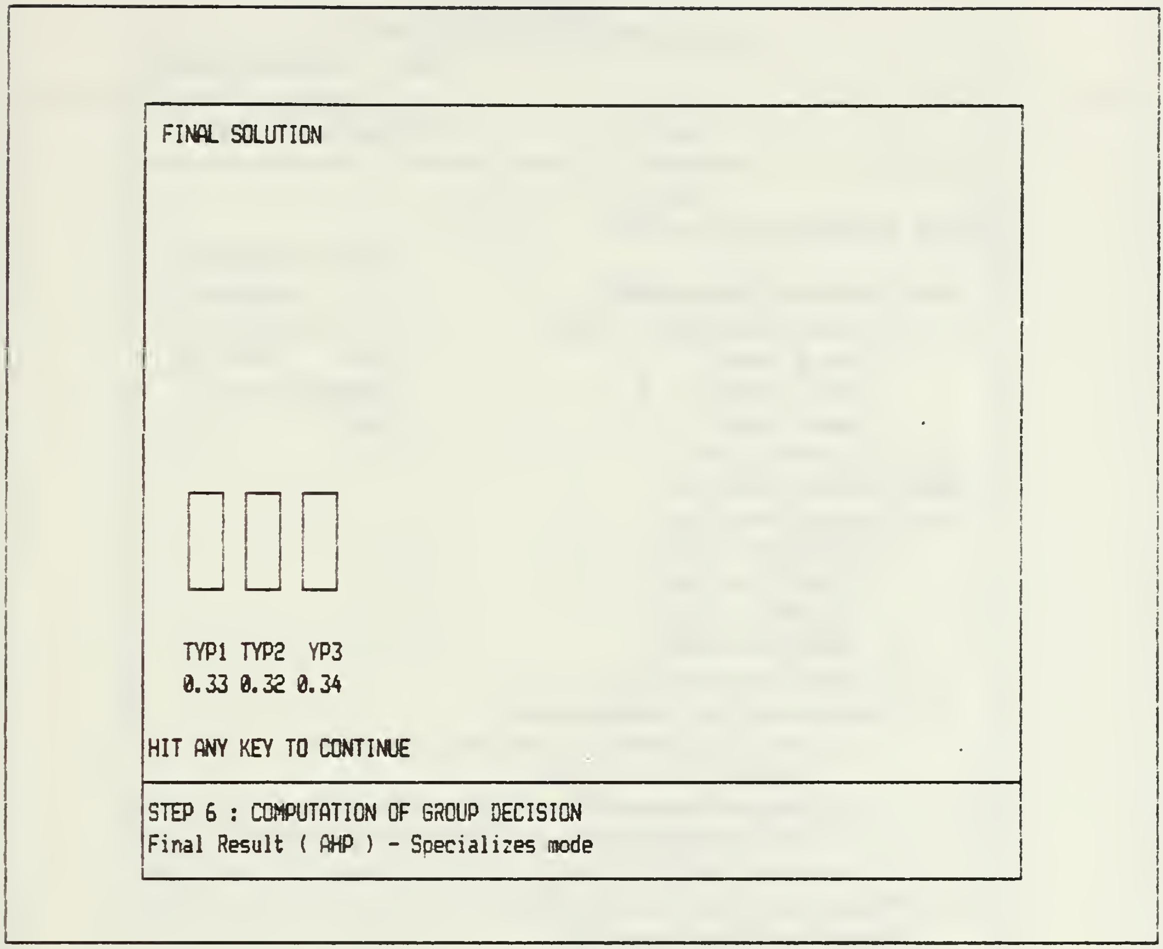


```
ALTERN.EVALUATION : WORKING AREA          PRIORITY VECTOR

     TYP1 TYP2 TYP3
SON                                       TYP1          0.36
AIR                                       TYP2          0.32
A/S                                       TYP3          0.32
MAI  8.00 7.00 7.00
GUN
```

```
Do you want to modify the weights (Y/N) ?
```

```
STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Direct input
```

Figure 22. User 1 / Evaluation of alternatives According to Criterion Maintance (DIRECT)

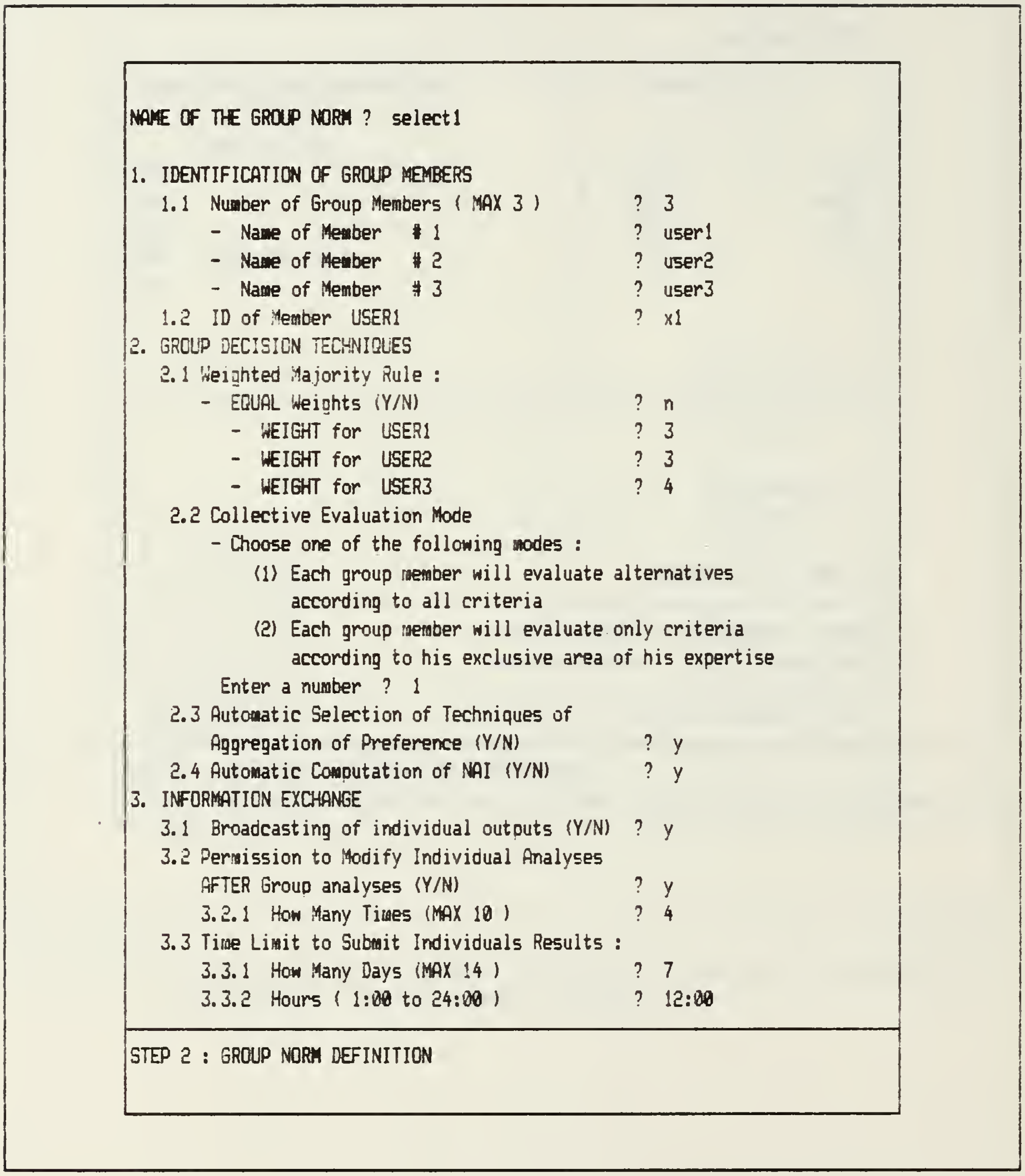


```
FINAL SOLUTION

  TYP1 TYP2  YP3
  0.33 0.32 0.34

HIT ANY KEY TO CONTINUE

STEP 6 : COMPUTATION OF GROUP DECISION
Final Result ( AHP ) - Specializes mode
```

Figure 23. Final Group Solution of the Problem

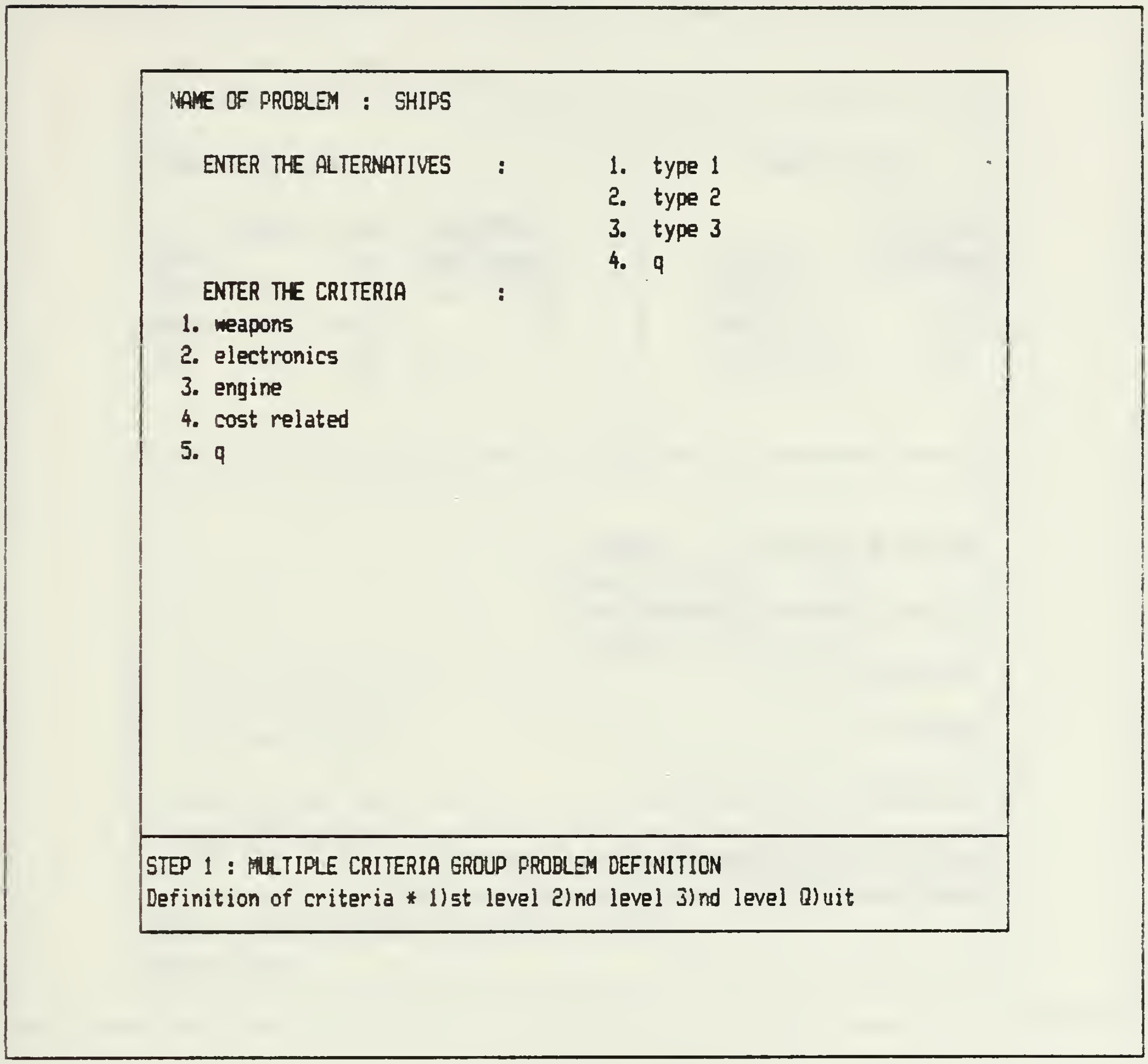
APPENDIX C

FIGURES FOR SCENARIO 2



```
NAME OF THE GROUP NORM ?  select1

1. IDENTIFICATION OF GROUP MEMBERS
   1.1  Number of Group Members ( MAX 3 )          ?  3
        -  Name of Member   # 1                    ?  user1
        -  Name of Member   # 2                    ?  user2
        -  Name of Member   # 3                    ?  user3
   1.2  ID of Member  USER1                        ?  x1
2. GROUP DECISION TECHNIQUES
   2.1 Weighted Majority Rule :
       -  EQUAL Weights (Y/N)                      ?  n
          -  WEIGHT for  USER1                     ?  3
          -  WEIGHT for  USER2                     ?  3
          -  WEIGHT for  USER3                     ?  4
    2.2 Collective Evaluation Mode
        - Choose one of the following modes :
            (1) Each group member will evaluate alternatives
                according to all criteria
            (2) Each group member will evaluate only criteria
                according to his exclusive area of his expertise
         Enter a number  ?  1
    2.3 Automatic Selection of Techniques of
        Aggregation of Preference (Y/N)             ?  y
    2.4 Automatic Computation of NAI (Y/N)          ?  y
3. INFORMATION EXCHANGE
   3.1  Broadcasting of individual outputs (Y/N)   ?  y
   3.2 Permission to Modify Individual Analyses
       AFTER Group analyses (Y/N)                  ?  y
       3.2.1  How Many Times (MAX 10 )             ?  4
   3.3 Time Limit to Submit Individuals Results :
       3.3.1  How Many Days (MAX 14 )              ?  7
       3.3.2  Hours ( 1:00 to 24:00 )              ?  12:00

STEP 2 : GROUP NORM DEFINITION
```

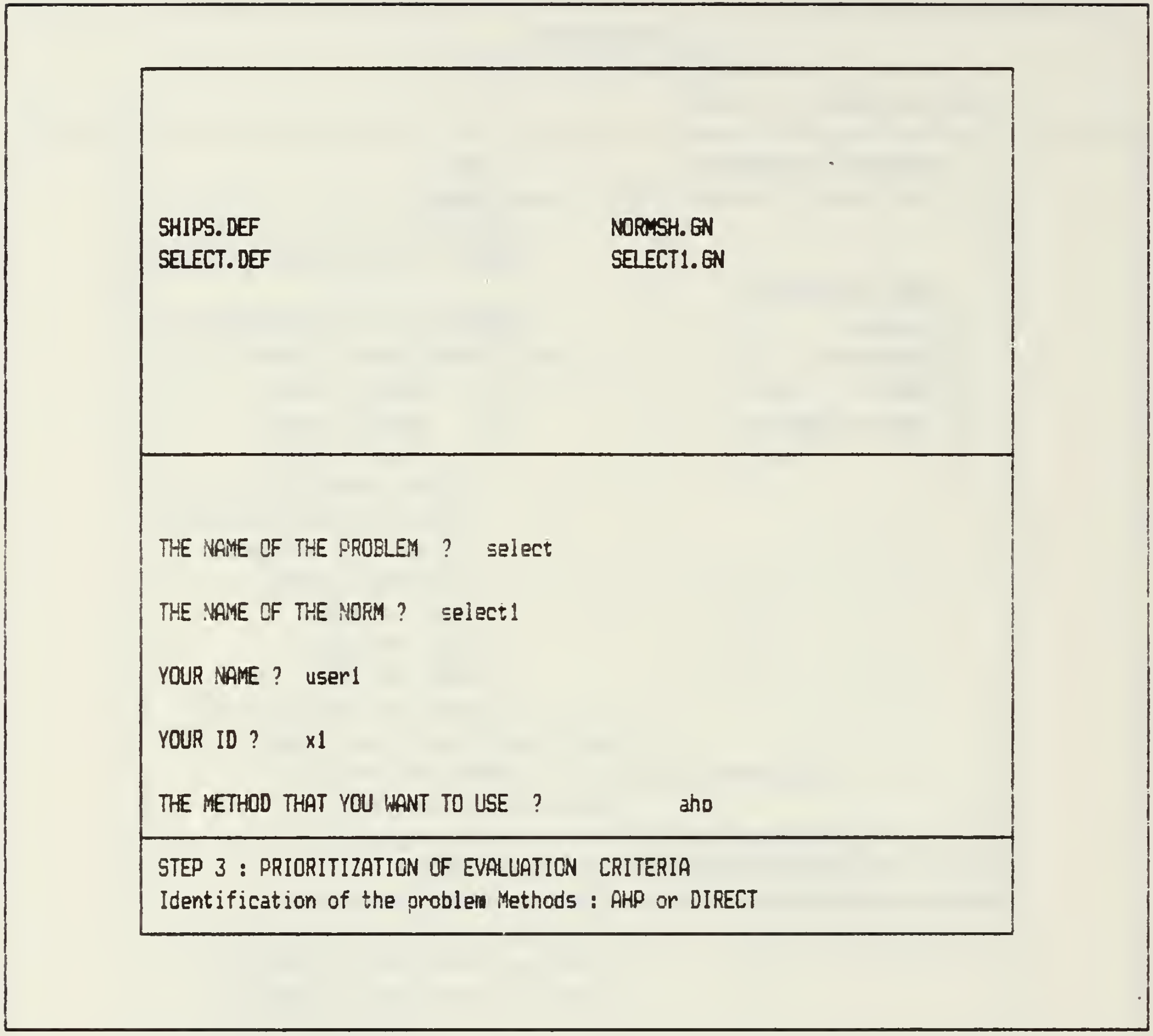
Figure 24. Group Norm Definition



```
NAME OF PROBLEM  :  SHIPS

   ENTER THE ALTERNATIVES    :        1.  type 1
                                      2.  type 2
                                      3.  type 3
                                      4.  q
   ENTER THE CRITERIA        :
 1. weapons
 2. electronics
 3. engine
 4. cost related
 5. q
```

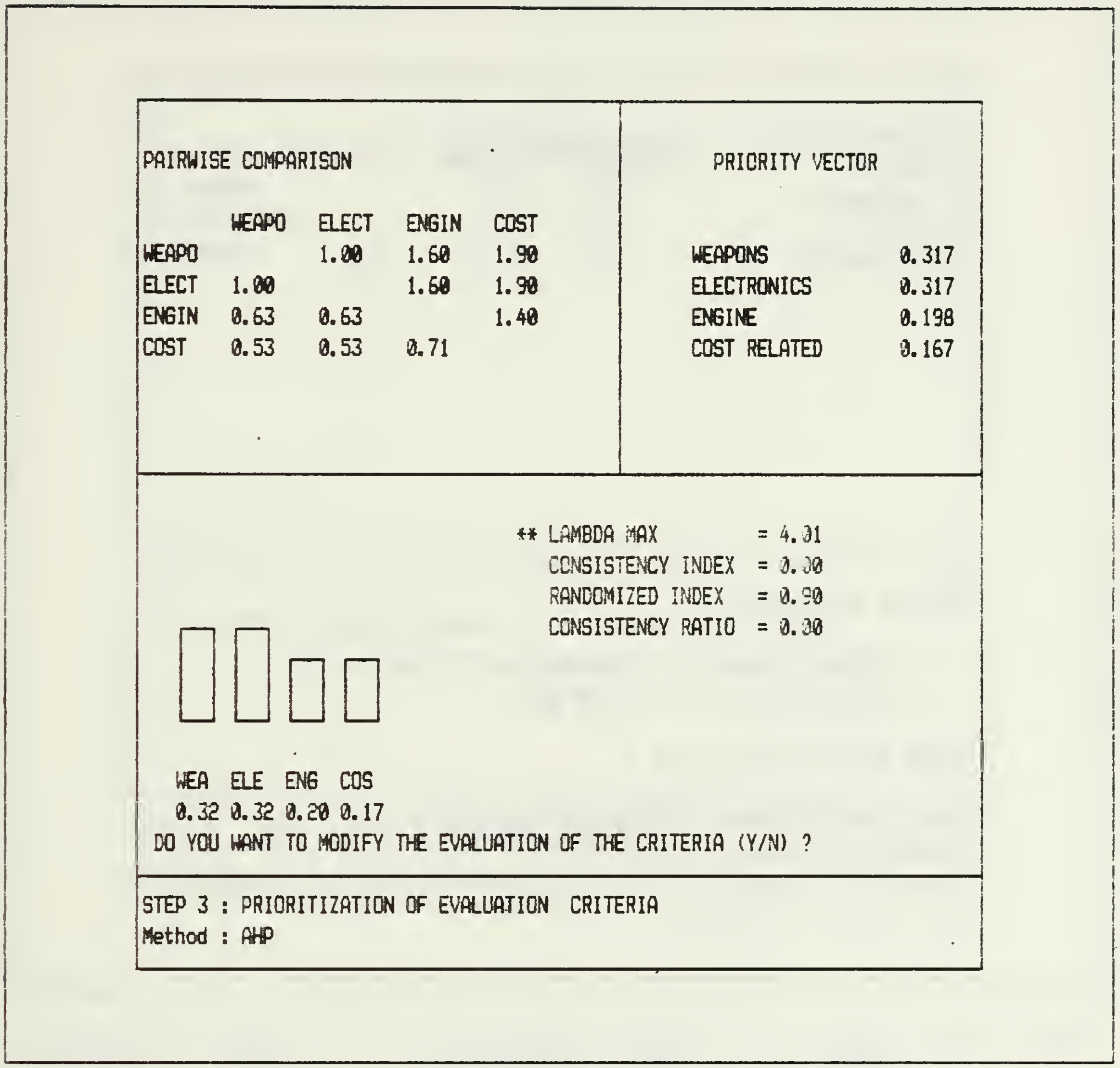
```
STEP 1 : MULTIPLE CRITERIA GROUP PROBLEM DEFINITION
Definition of criteria * 1)st level 2)nd level 3)nd level Q)uit
```

Figure 25. 1 Group Problem Definition



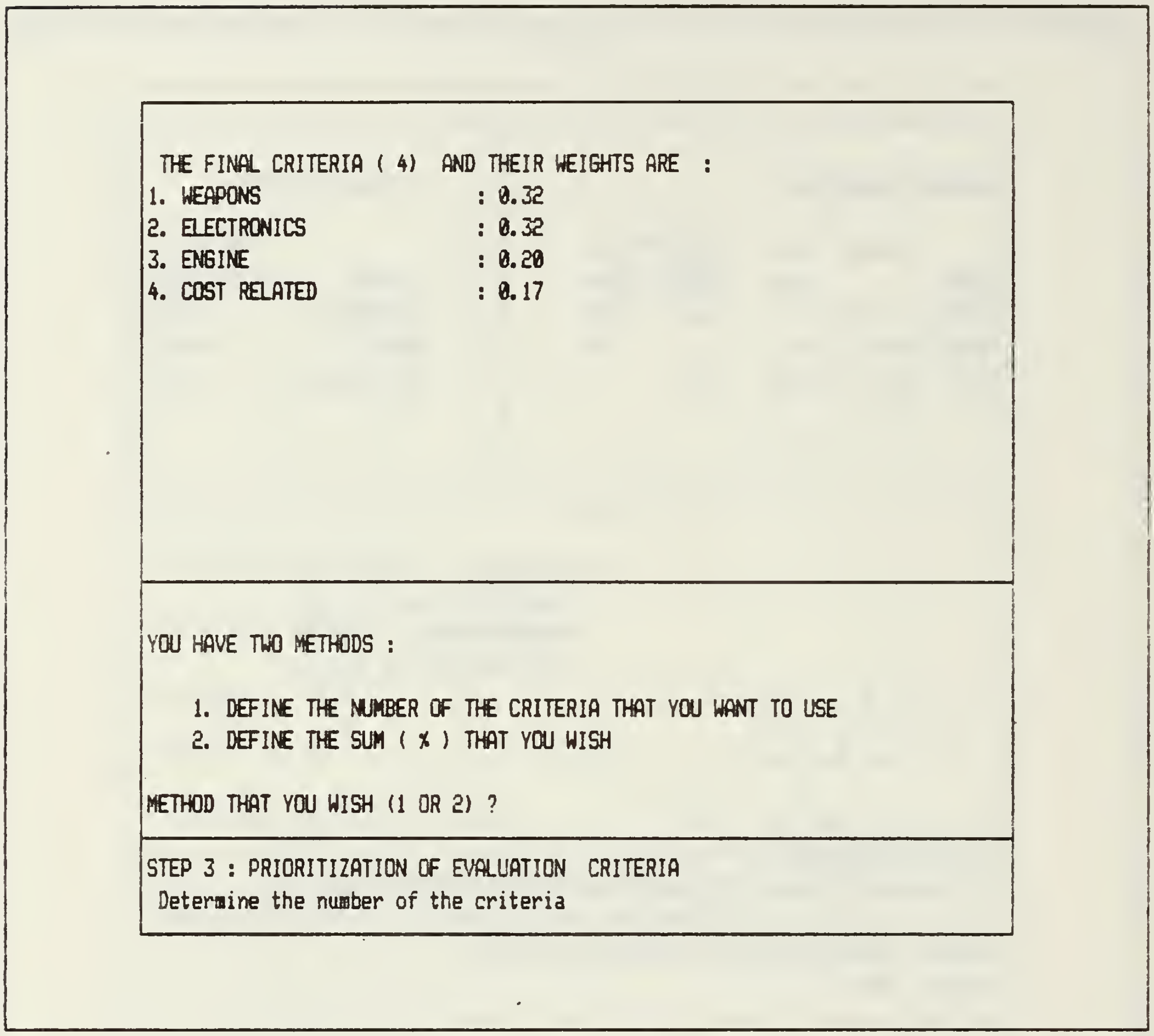
```
SHIPS.DEF                                NORMSH.GN
SELECT.DEF                               SELECT1.GN

THE NAME OF THE PROBLEM  ?   select

THE NAME OF THE NORM ?   select1

YOUR NAME ?  user1

YOUR ID ?    x1

THE METHOD THAT YOU WANT TO USE  ?          ahp

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Identification of the problem Methods : AHP or DIRECT
```

Figure 26. User 1 / Problem Initiation



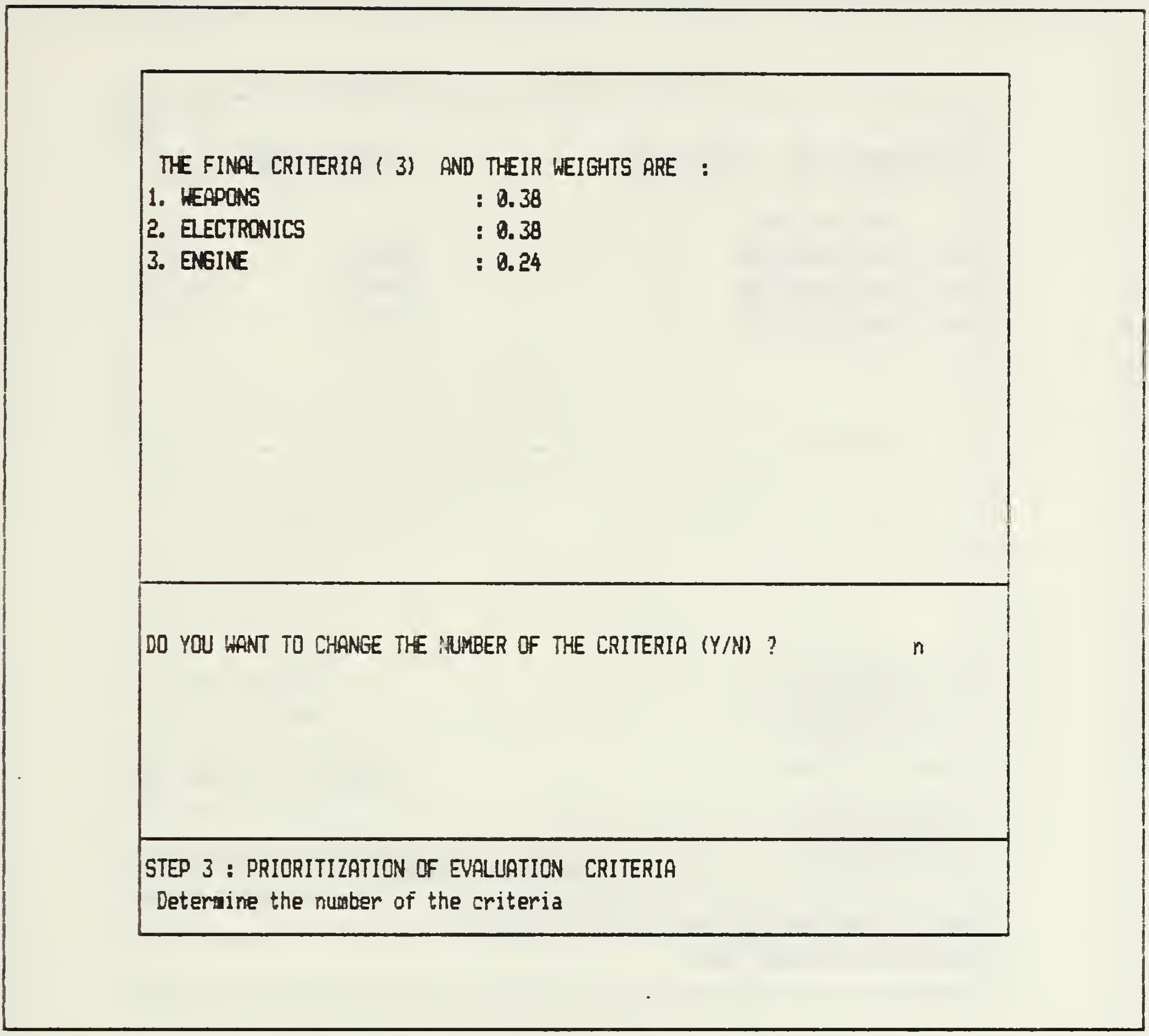
```
PAIRWISE COMPARISON                              PRIORITY VECTOR

        WEAPO   ELECT   ENGIN   COST
WEAPO           1.00    1.60    1.90         WEAPONS            0.317
ELECT   1.00            1.60    1.90         ELECTRONICS        0.317
ENGIN   0.63    0.63            1.40         ENGINE             0.198
COST    0.53    0.53    0.71                 COST RELATED       0.167


                                      ** LAMBDA MAX         = 4.01
                                         CONSISTENCY INDEX  = 0.00
                                         RANDOMIZED INDEX   = 0.90
                                         CONSISTENCY RATIO  = 0.00


   WEA  ELE  ENG  COS
   0.32 0.32 0.20 0.17
 DO YOU WANT TO MODIFY THE EVALUATION OF THE CRITERIA (Y/N) ?

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
Method : AHP
```

Figure 27. User 1 / Prioritization of Evaluation Criteria (AHP)



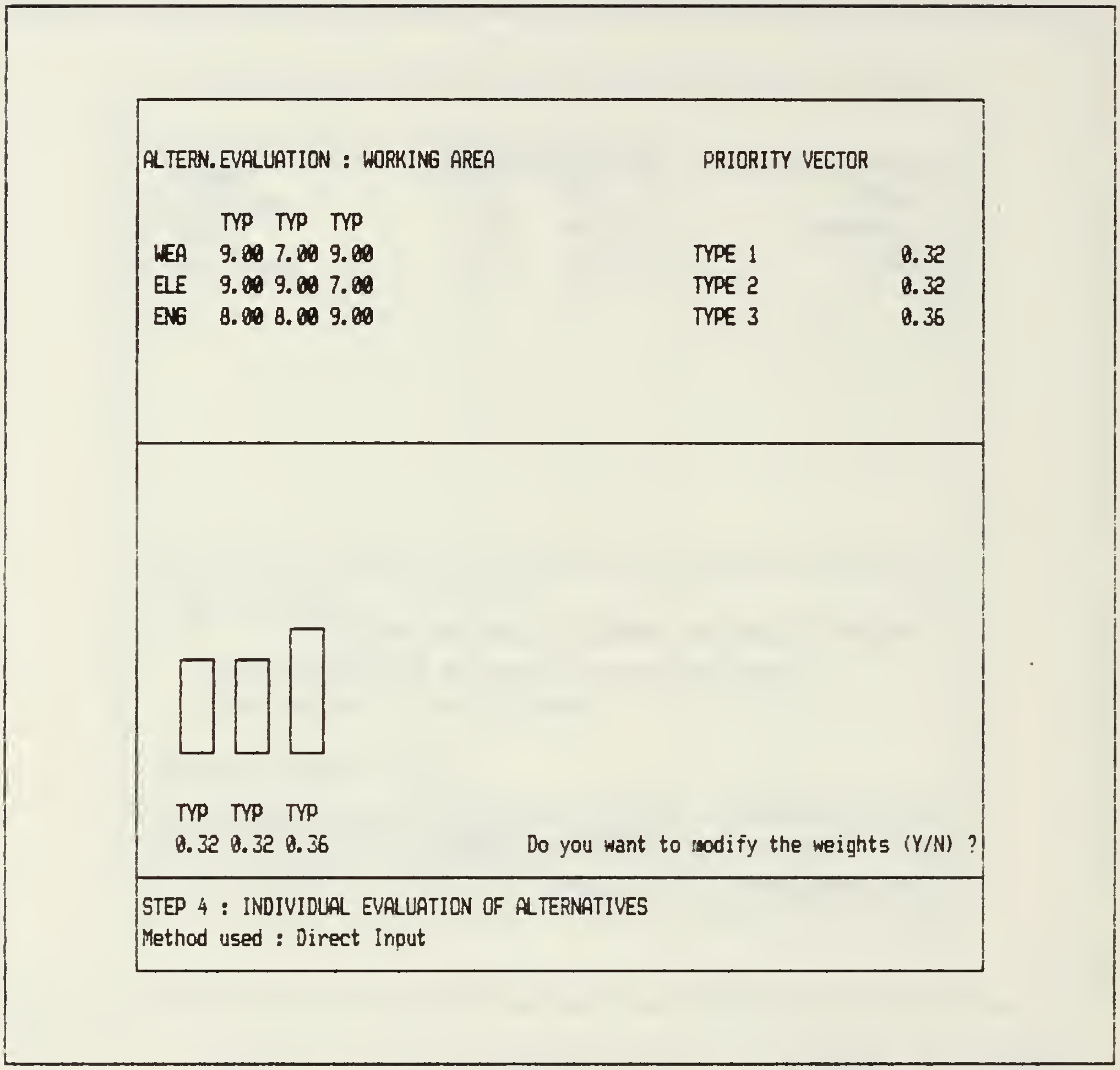
```
 THE FINAL CRITERIA ( 4)  AND THEIR WEIGHTS ARE  :
1. WEAPONS                : 0.32
2. ELECTRONICS            : 0.32
3. ENGINE                 : 0.20
4. COST RELATED           : 0.17

YOU HAVE TWO METHODS :

    1. DEFINE THE NUMBER OF THE CRITERIA THAT YOU WANT TO USE
    2. DEFINE THE SUM ( % ) THAT YOU WISH

METHOD THAT YOU WISH (1 OR 2) ?

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
 Determine the number of the criteria
```

Figure 28. User 1 / Final Weights of Evaluation Criteria



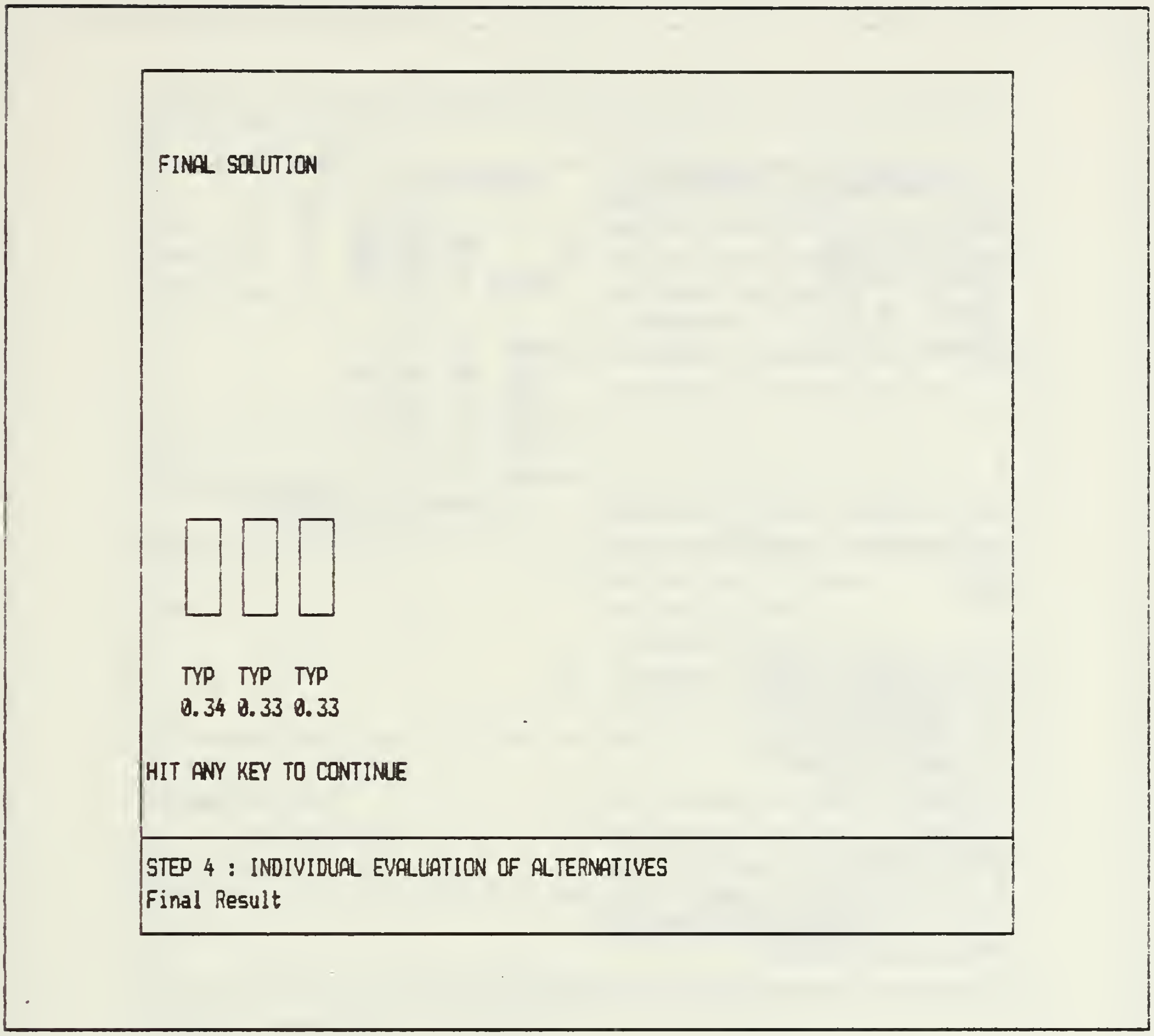
```
 THE FINAL CRITERIA ( 3)  AND THEIR WEIGHTS ARE  :
1. WEAPONS                   : 0.38
2. ELECTRONICS               : 0.38
3. ENGINE                    : 0.24

DO YOU WANT TO CHANGE THE NUMBER OF THE CRITERIA (Y/N) ?           n

STEP 3 : PRIORITIZATION OF EVALUATION  CRITERIA
 Determine the number of the criteria
```

FIGURE 29. USER 1 / THE REDUCED SET OF CRITERIA



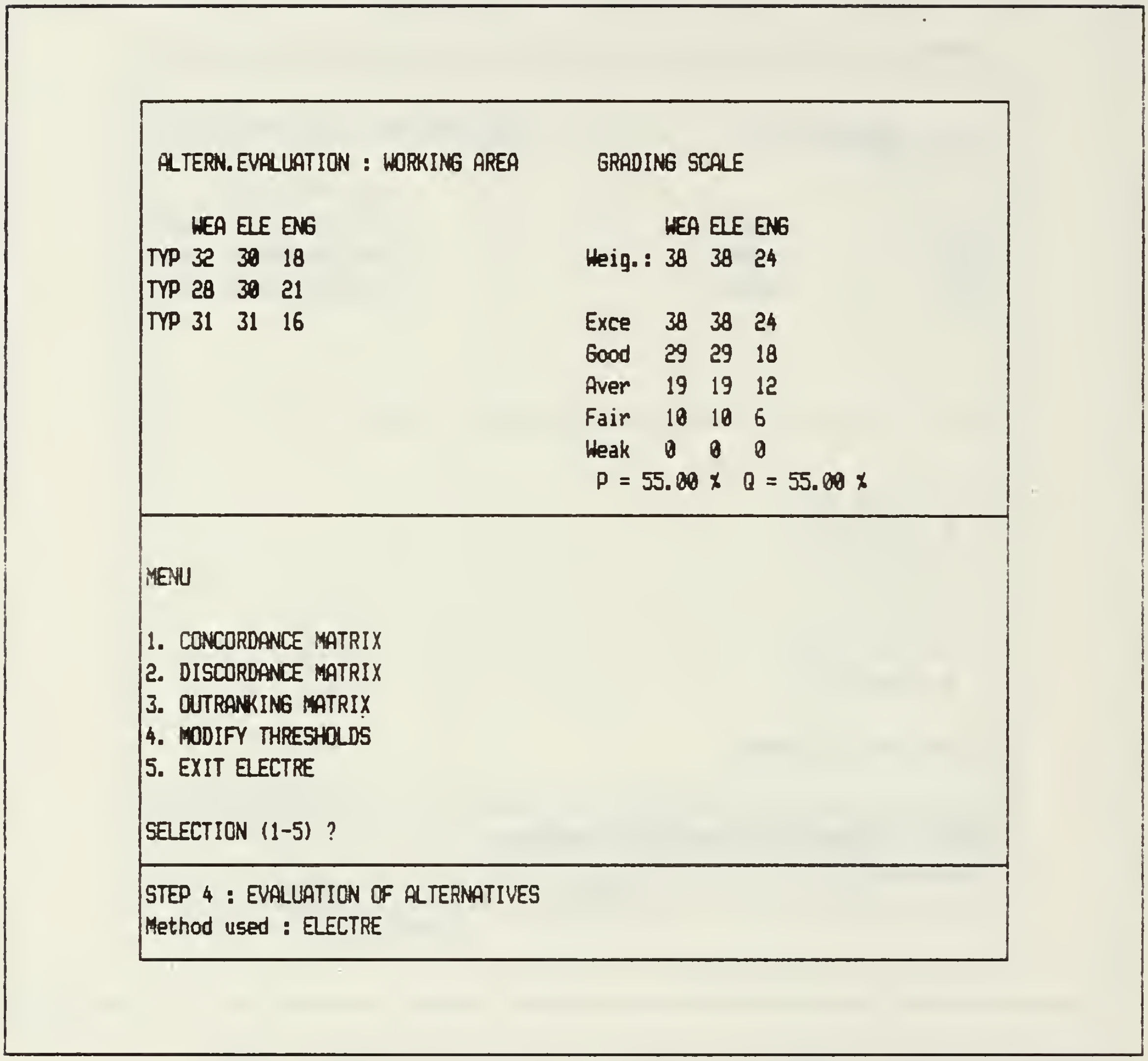
```
ALTERN.EVALUATION : WORKING AREA                    PRIORITY VECTOR

      TYP  TYP  TYP
 WEA  9.00 7.00 9.00                               TYPE 1          0.32
 ELE  9.00 9.00 7.00                               TYPE 2          0.32
 ENG  8.00 8.00 9.00                               TYPE 3          0.36



   TYP  TYP  TYP
   0.32 0.32 0.36                       Do you want to modify the weights (Y/N) ?

STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Method used : Direct Input
```

Figure 30. User 1 / Individual Evaluation of Alternatives Using Direct mode



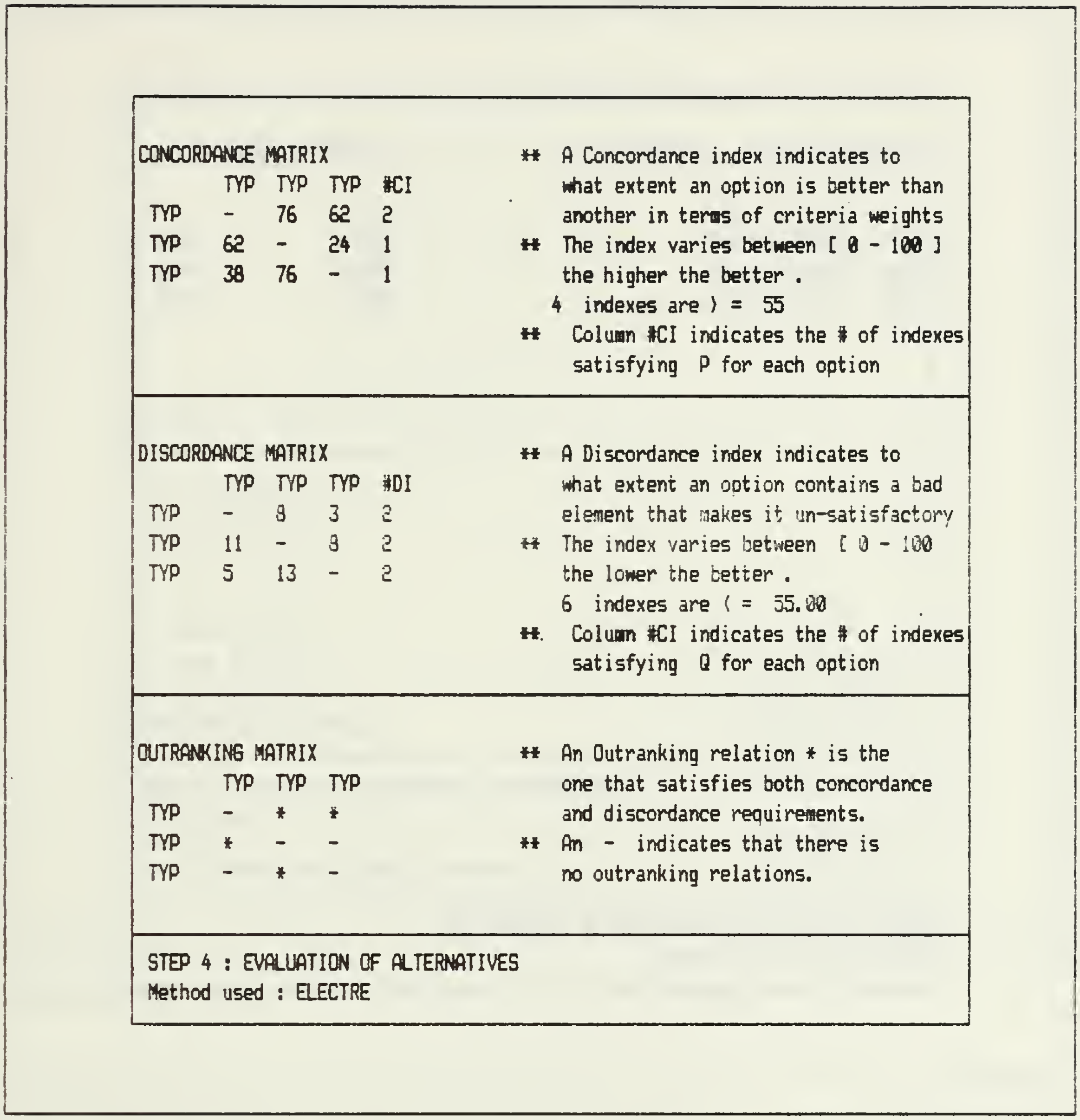
```
FINAL SOLUTION

 TYP  TYP  TYP
 0.34 0.33 0.33

HIT ANY KEY TO CONTINUE

STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Final Result
```

Figure 31. Solution of User 1 (With Direct Mode)



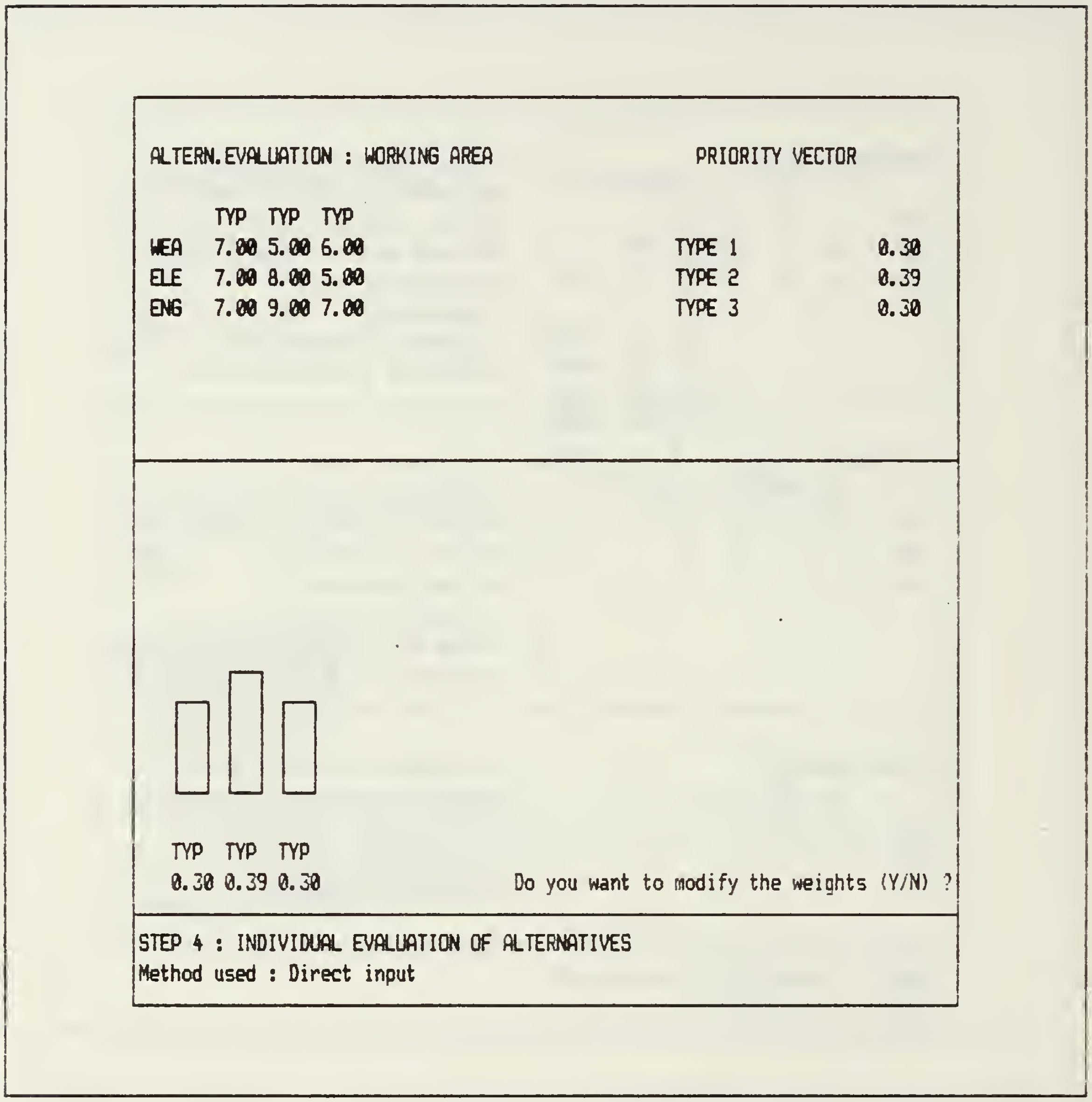
```
 ALTERN.EVALUATION : WORKING AREA      GRADING SCALE

    WEA ELE ENG                              WEA ELE ENG
TYP 32  30  18                       Weig.: 38  38  24
TYP 28  30  21
TYP 31  31  16                       Exce   38  38  24
                                     Good   29  29  18
                                     Aver   19  19  12
                                     Fair   10  10  6
                                     Weak   0   0   0
                                      P = 55.00 %  Q = 55.00 %

MENU

1. CONCORDANCE MATRIX
2. DISCORDANCE MATRIX
3. OUTRANKING MATRIX
4. MODIFY THRESHOLDS
5. EXIT ELECTRE

SELECTION (1-5) ?

STEP 4 : EVALUATION OF ALTERNATIVES
Method used : ELECTRE
```

Figure 32. User 1 / Evaluation of Alternatives Using Electre



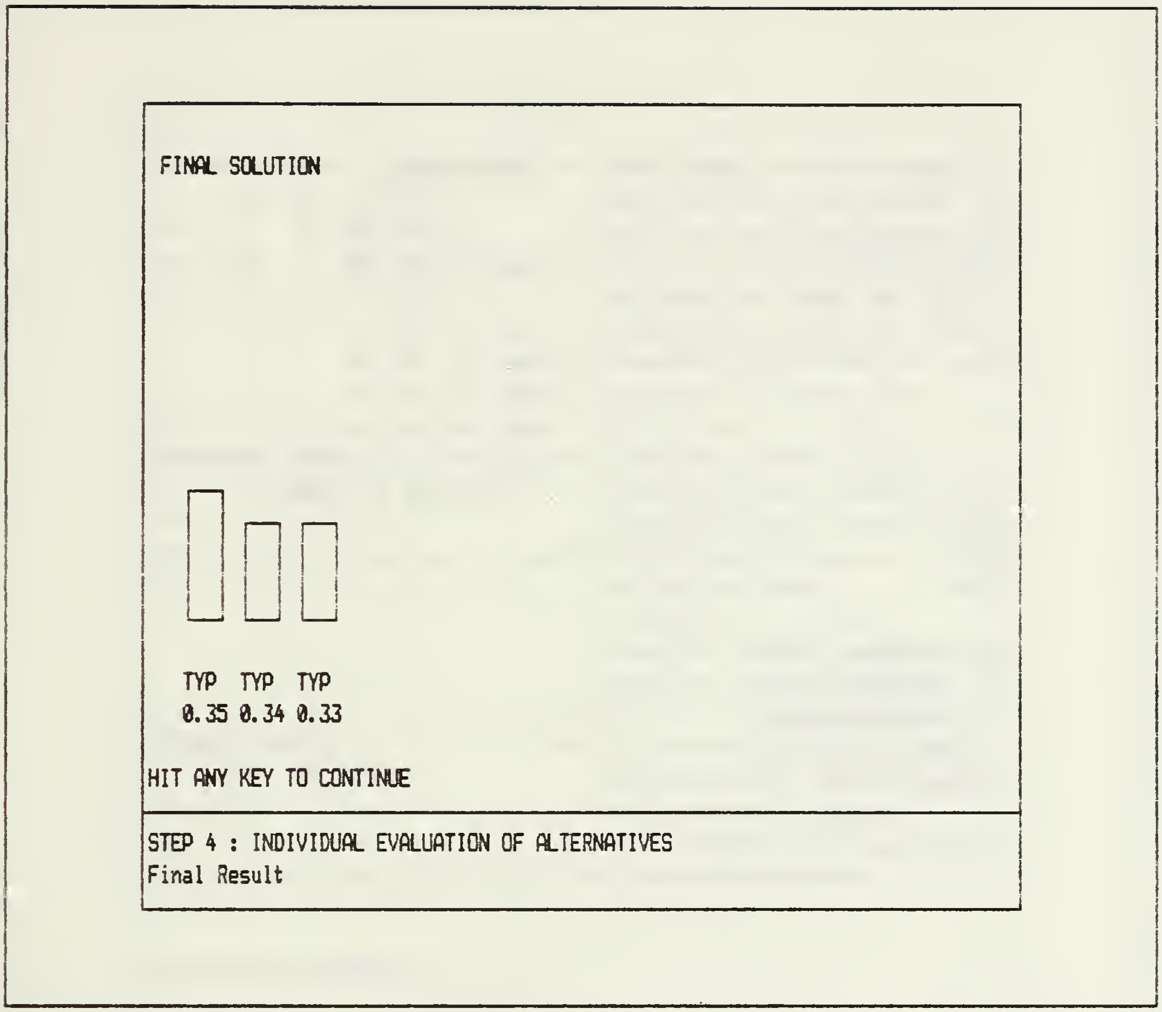
```
CONCORDANCE MATRIX                    **  A Concordance index indicates to
        TYP  TYP  TYP  #CI                what extent an option is better than
 TYP     -    76   62   2                 another in terms of criteria weights
 TYP    62    -    24   1             **  The index varies between [ 0 - 100 ]
 TYP    38    76   -    1                 the higher the better .
                                        4  indexes are ) =  55
                                      **   Column #CI indicates the # of indexes
                                           satisfying  P for each option

DISCORDANCE MATRIX                    **  A Discordance index indicates to
        TYP  TYP  TYP  #DI                what extent an option contains a bad
 TYP     -    8    3    2                 element that makes it un-satisfactory
 TYP    11    -    8    2             **  The index varies between  [ 0 - 100
 TYP     5    13   -    2                 the lower the better .
                                          6  indexes are ( =  55.00
                                      **.  Column #CI indicates the # of indexes
                                           satisfying  Q for each option

OUTRANKING MATRIX                     **  An Outranking relation * is the
        TYP  TYP  TYP                     one that satisfies both concordance
 TYP     -    *    *                      and discordance requirements.
 TYP     *    -    -                  **  An  -  indicates that there is
 TYP     -    *    -                      no outranking relations.

 STEP 4 : EVALUATION OF ALTERNATIVES
 Method used : ELECTRE
```

Figure 33. User 1 / Concordance, Discordance, Outranking Matrix



```
ALTERN.EVALUATION : WORKING AREA                    PRIORITY VECTOR

      TYP  TYP  TYP
WEA   7.00 5.00 6.00                              TYPE 1            0.30
ELE   7.00 8.00 5.00                              TYPE 2            0.39
ENG   7.00 9.00 7.00                              TYPE 3            0.30



  TYP  TYP  TYP
  0.30 0.39 0.30                        Do you want to modify the weights (Y/N) ?

STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Method used : Direct input
```

Figure 34. User2 / Individual Evaluation of Alternatives Using Direct Mode

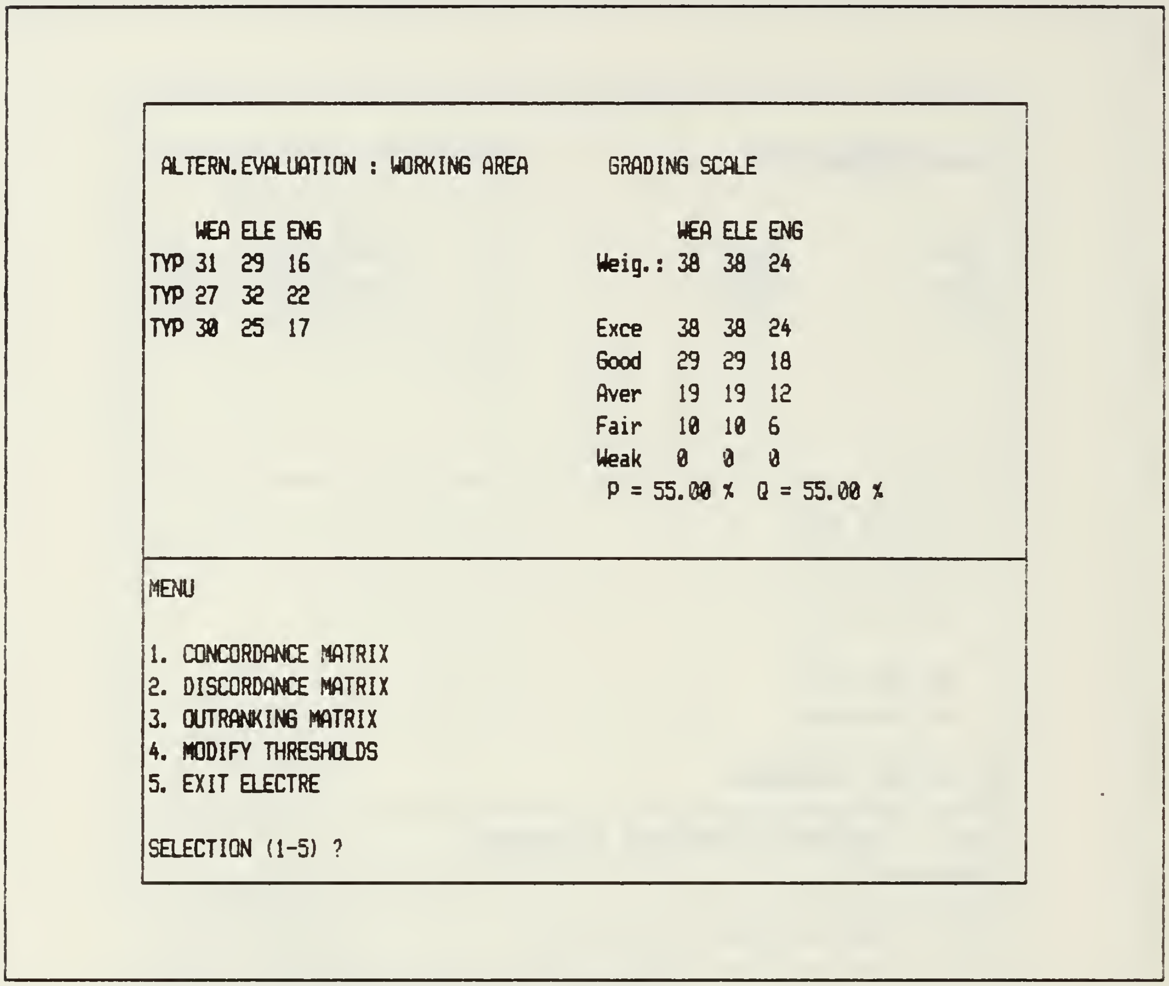


FINAL SOLUTION

HIT ANY KEY TO CONTINUE

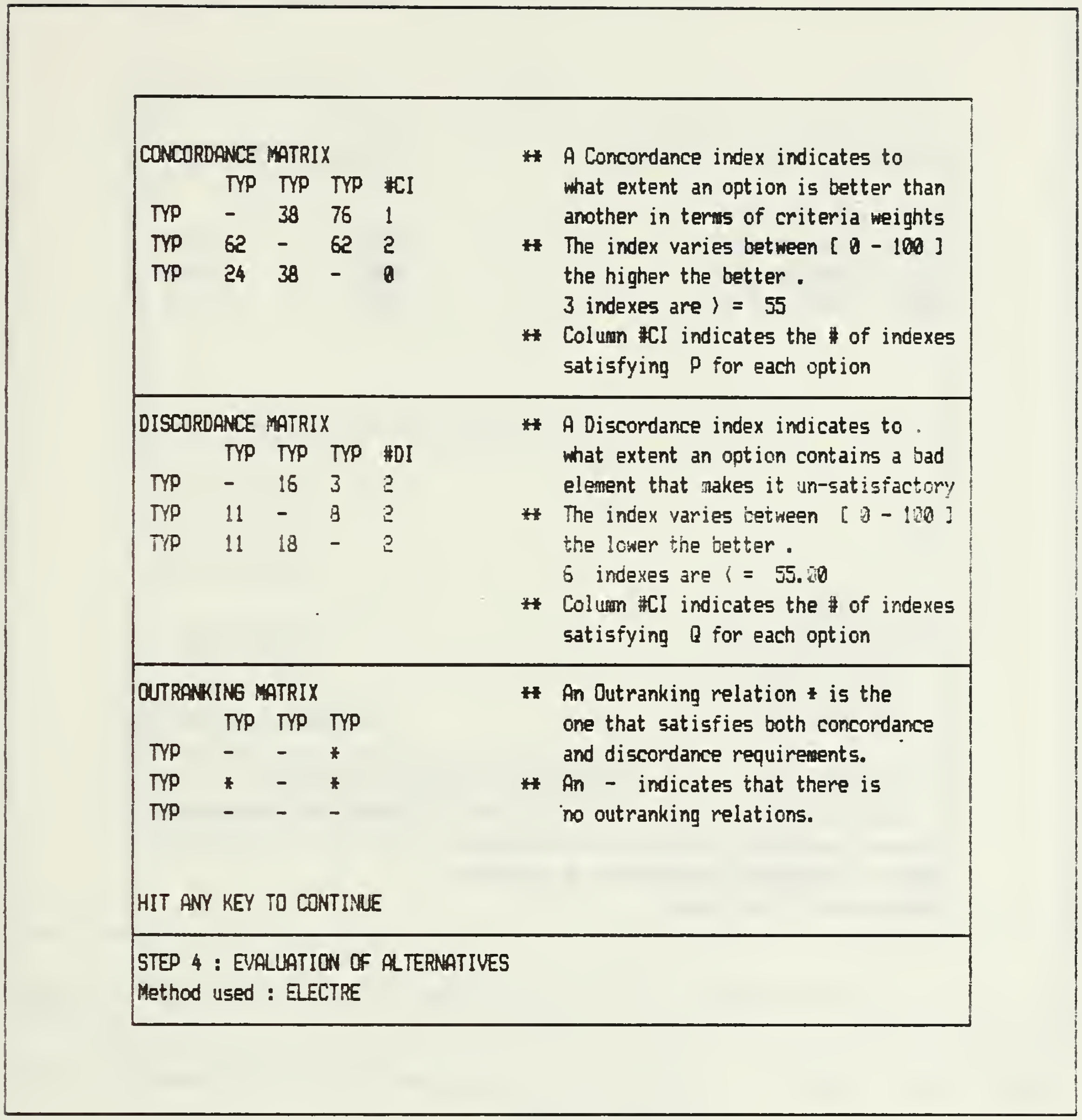
STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Final Result

Figure 35. Solution of User 2 (With Direct Mode)



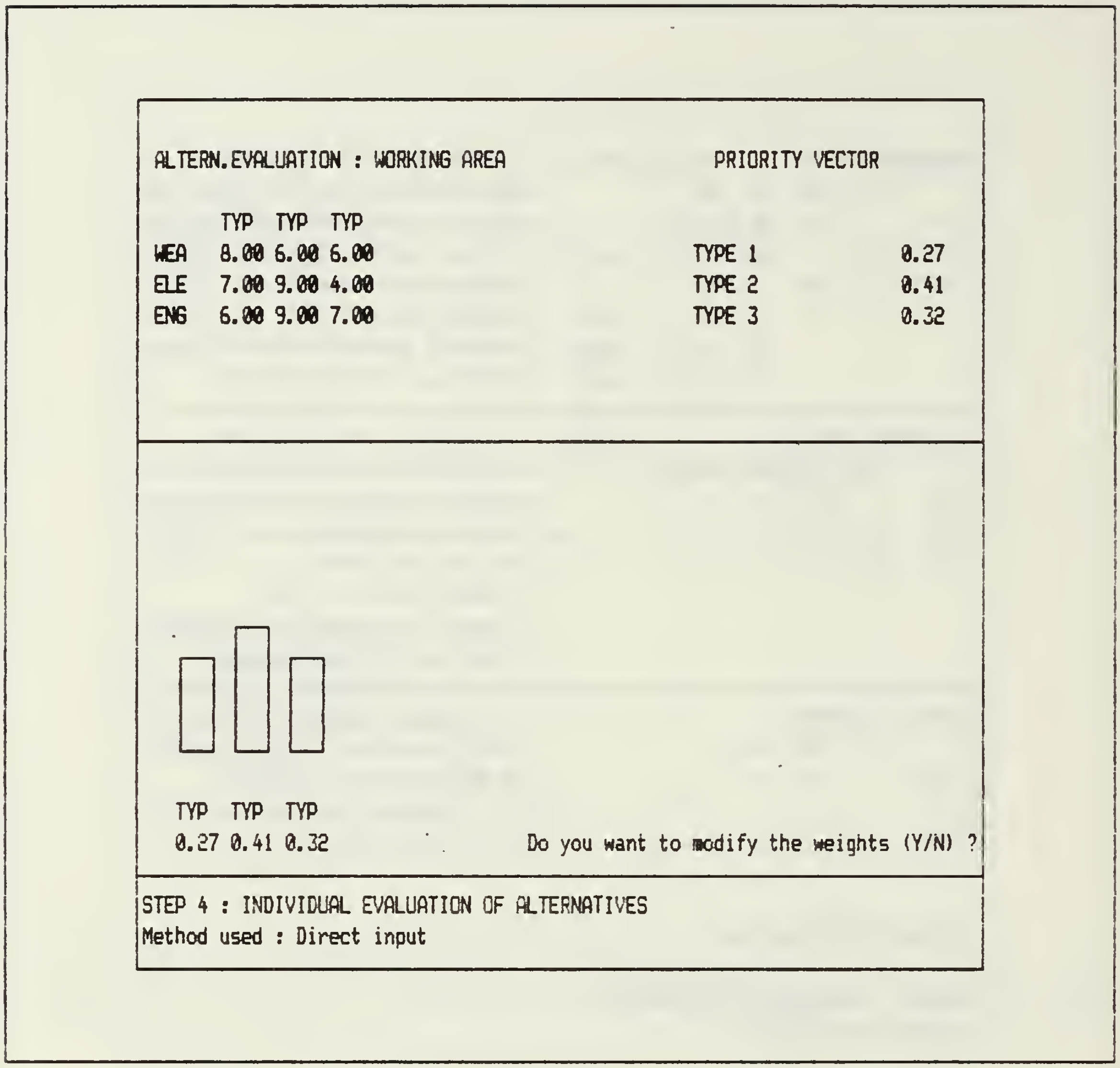
```
ALTERN.EVALUATION : WORKING AREA      GRADING SCALE

   WEA ELE ENG                              WEA ELE ENG
TYP 31  29  16                       Weig.: 38  38  24
TYP 27  32  22
TYP 30  25  17                       Exce   38  38  24
                                     Good   29  29  18
                                     Aver   19  19  12
                                     Fair   10  10  6
                                     Weak   0   0   0
                                      P = 55.00 %  Q = 55.00 %

MENU

1. CONCORDANCE MATRIX
2. DISCORDANCE MATRIX
3. OUTRANKING MATRIX
4. MODIFY THRESHOLDS
5. EXIT ELECTRE

SELECTION (1-5) ?
```

Figure 36. User 2 / Evaluation of Alternatives Using Electre



```
CONCORDANCE MATRIX                      ** A Concordance index indicates to
        TYP  TYP  TYP  #CI                 what extent an option is better than
 TYP    -    38   76   1                   another in terms of criteria weights
 TYP    62   -    62   2                ** The index varies between [ 0 - 100 ]
 TYP    24   38   -    0                   the higher the better .
                                           3 indexes are ) =  55
                                        ** Column #CI indicates the # of indexes
                                           satisfying  P for each option

DISCORDANCE MATRIX                      ** A Discordance index indicates to .
        TYP  TYP  TYP  #DI                 what extent an option contains a bad
 TYP    -    16   3    2                   element that makes it un-satisfactory
 TYP    11   -    8    2                ** The index varies between  [ 0 - 100 ]
 TYP    11   18   -    2                   the lower the better .
                                           6  indexes are ( =  55.00
                                        ** Column #CI indicates the # of indexes
                                           satisfying  Q for each option

OUTRANKING MATRIX                       ** An Outranking relation * is the
        TYP  TYP  TYP                      one that satisfies both concordance
 TYP    -    -    *                        and discordance requirements.
 TYP    *    -    *                     ** An  -  indicates that there is
 TYP    -    -    -                        no outranking relations.


HIT ANY KEY TO CONTINUE

STEP 4 : EVALUATION OF ALTERNATIVES
Method used : ELECTRE
```

Figure 37. User 2 / Concordance, Discordance, Outranking Matrix

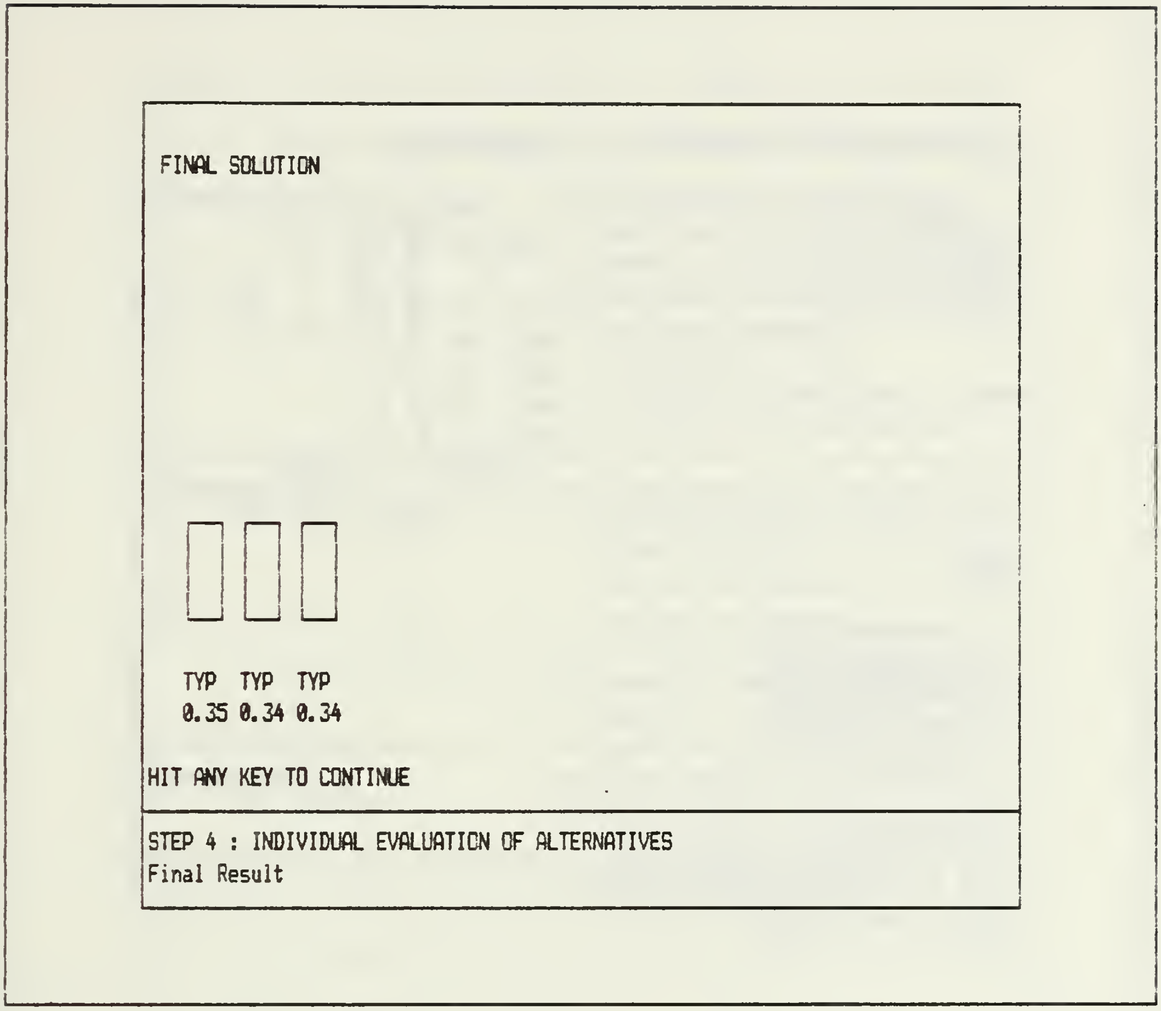


```
ALTERN.EVALUATION : WORKING AREA                 PRIORITY VECTOR

      TYP  TYP  TYP
WEA   8.00 6.00 6.00                           TYPE 1          0.27
ELE   7.00 9.00 4.00                           TYPE 2          0.41
ENG   6.00 9.00 7.00                           TYPE 3          0.32
```

```
  TYP  TYP  TYP
  0.27 0.41 0.32             Do you want to modify the weights (Y/N) ?
```

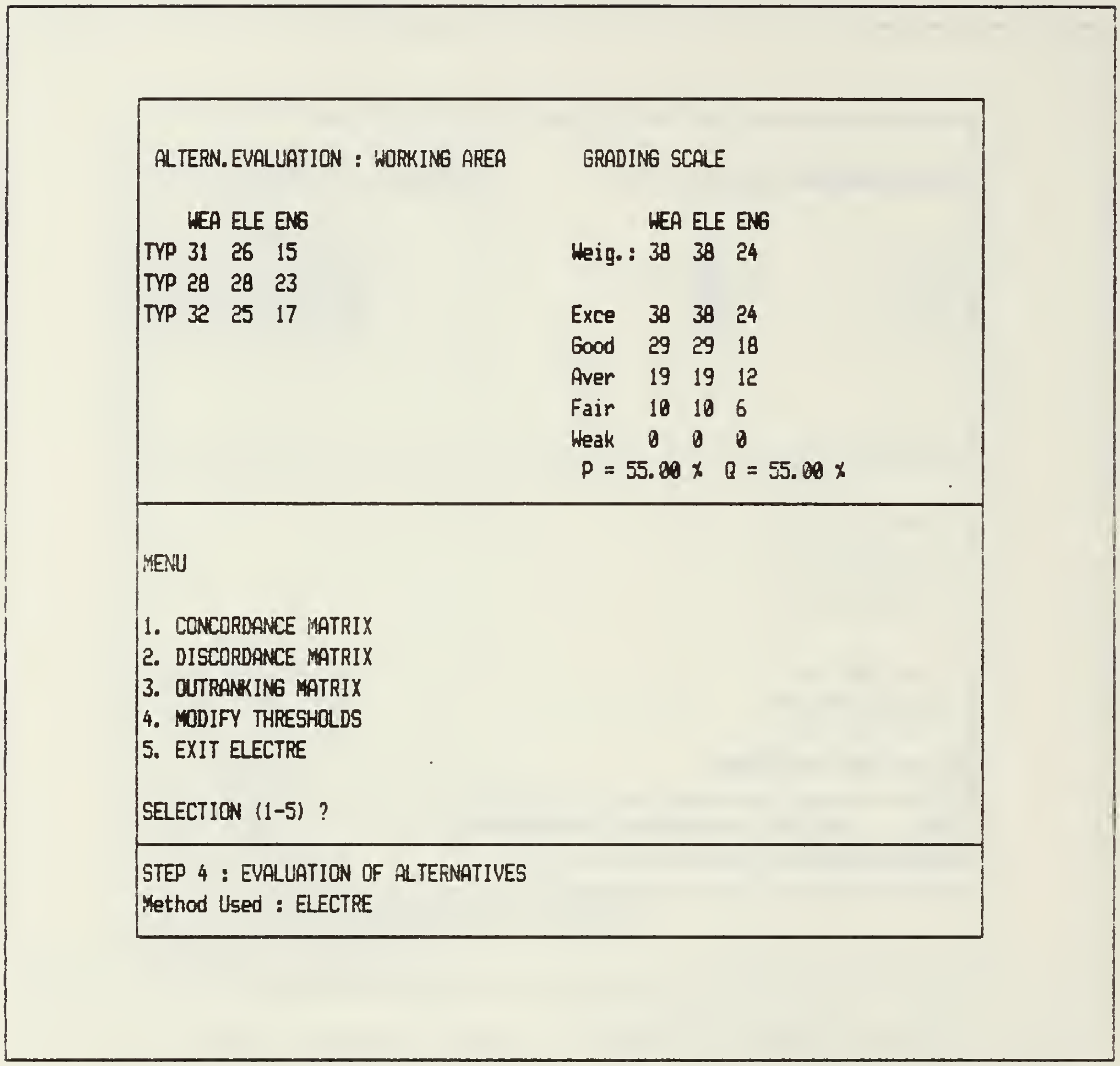
```
STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Method used : Direct input
```

Figure 38. User 3 / Individual Evaluation of Alternatives Using Direct Mode



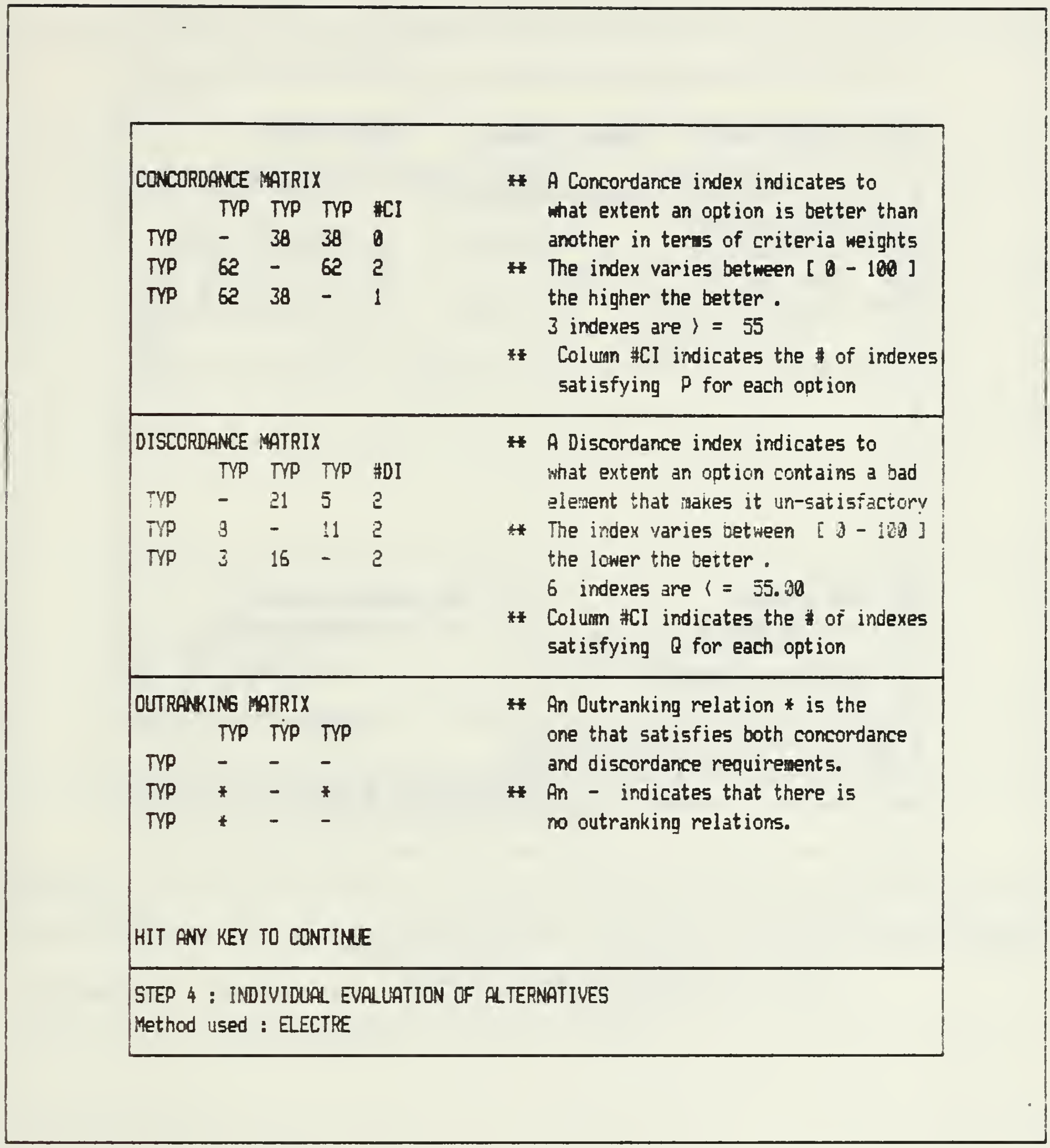
```
FINAL SOLUTION

TYP  TYP  TYP
0.35 0.34 0.34

HIT ANY KEY TO CONTINUE

STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Final Result
```

Figure 39. Solution of User 3 (With Direct Mode)



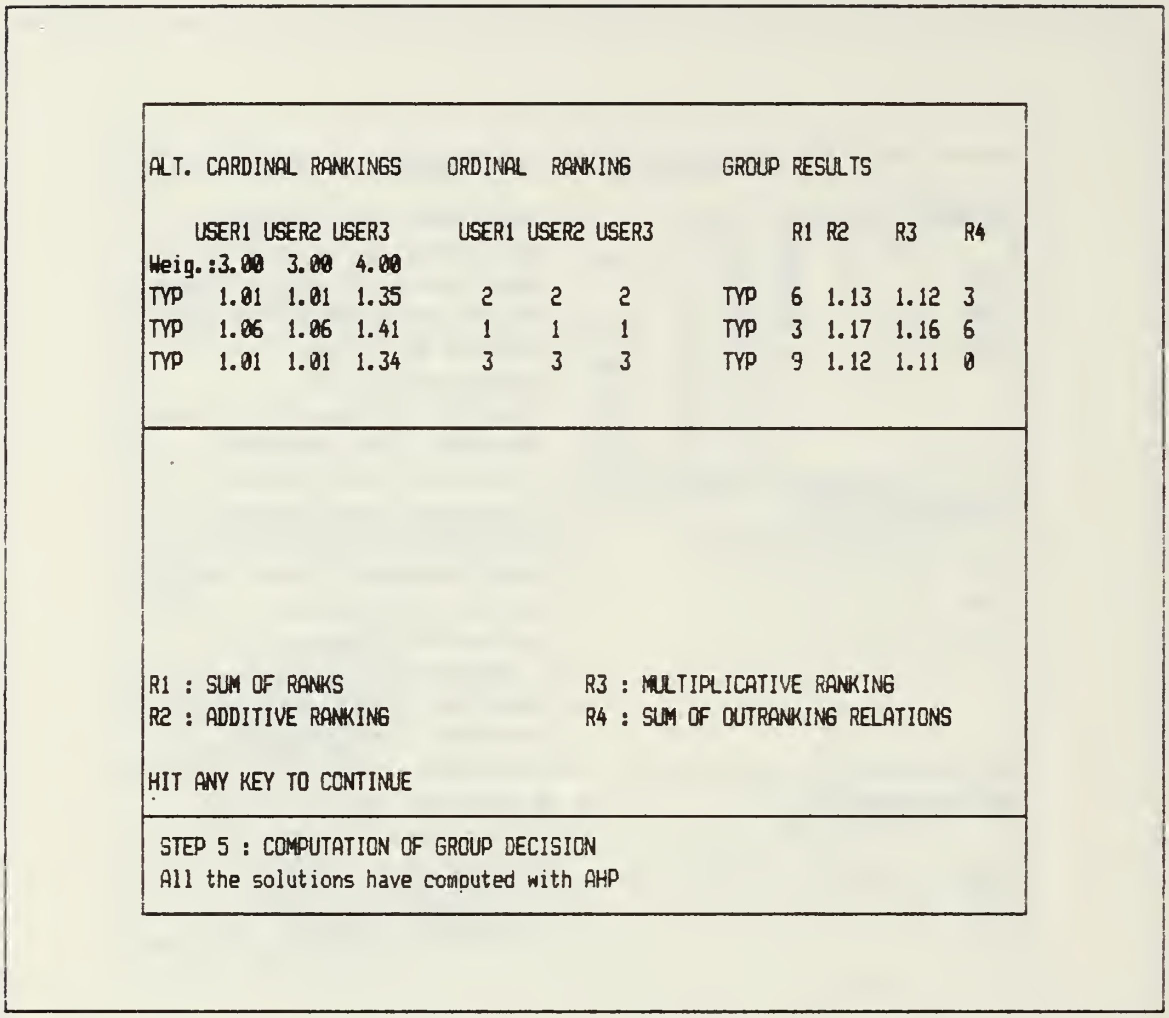
```
 ALTERN.EVALUATION : WORKING AREA       GRADING SCALE

   WEA ELE ENG                                WEA ELE ENG
TYP 31  26  15                         Weig.: 38  38  24
TYP 28  28  23
TYP 32  25  17                         Exce   38  38  24
                                       Good   29  29  18
                                       Aver   19  19  12
                                       Fair   10  10  6
                                       Weak   0   0   0
                                        P = 55.00 %  Q = 55.00 %

MENU

1. CONCORDANCE MATRIX
2. DISCORDANCE MATRIX
3. OUTRANKING MATRIX
4. MODIFY THRESHOLDS
5. EXIT ELECTRE

SELECTION (1-5) ?

STEP 4 : EVALUATION OF ALTERNATIVES
Method Used : ELECTRE
```

Figure 40. User 3 / Evaluation of Alternatives Using Electre



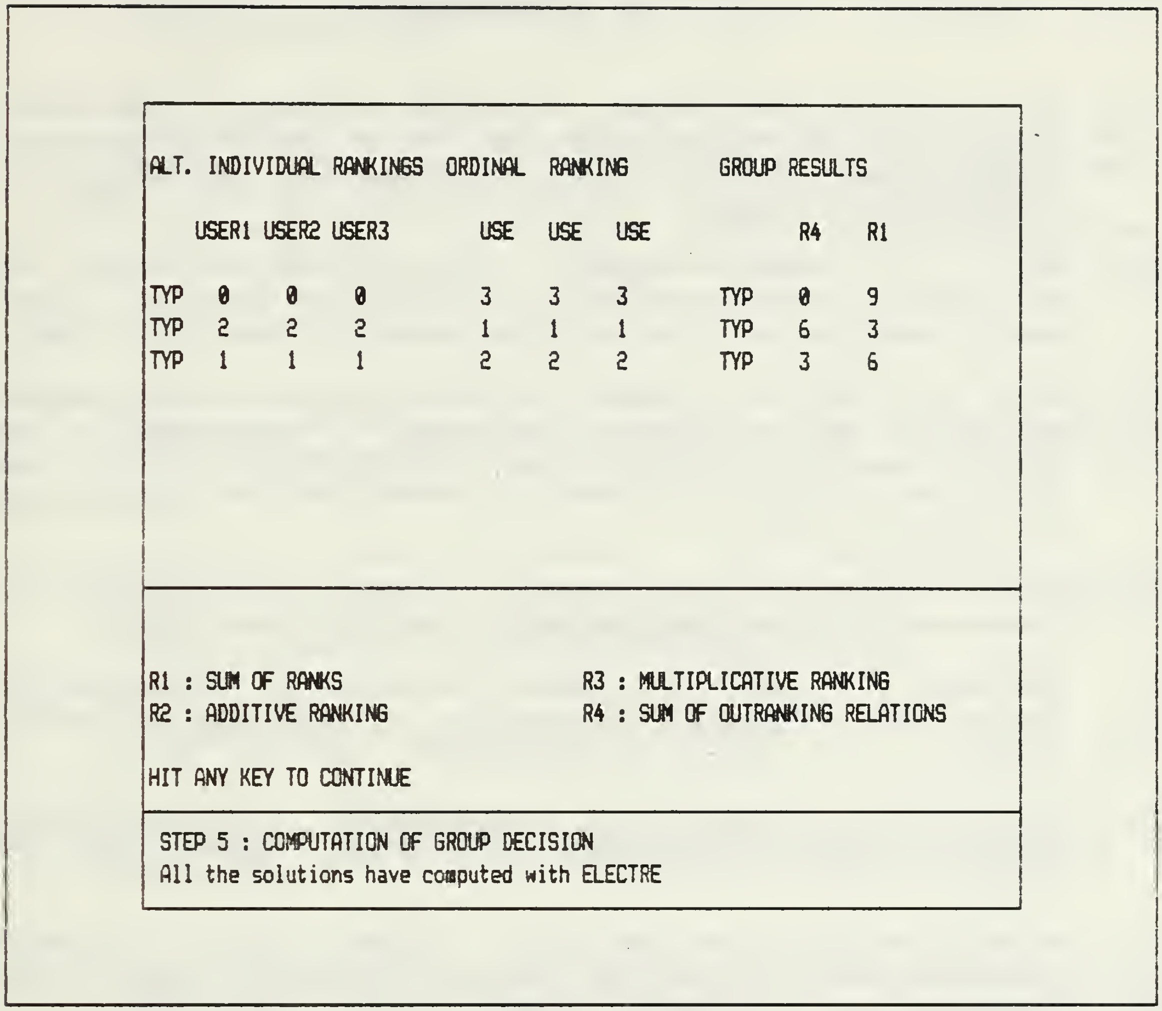
```
CONCORDANCE MATRIX                     **  A Concordance index indicates to
       TYP  TYP  TYP  #CI                  what extent an option is better than
 TYP   -    38   38   0                    another in terms of criteria weights
 TYP   62   -    62   2                **  The index varies between [ 0 - 100 ]
 TYP   62   38   -    1                    the higher the better .
                                           3 indexes are ) =  55
                                       **   Column #CI indicates the # of indexes
                                            satisfying  P for each option

DISCORDANCE MATRIX                     **  A Discordance index indicates to
       TYP  TYP  TYP  #DI                  what extent an option contains a bad
 TYP   -    21   5    2                    element that makes it un-satisfactory
 TYP   8    -    11   2                **  The index varies between  [ 0 - 100 ]
 TYP   3    16   -    2                    the lower the better .
                                           6  indexes are ( =  55.00
                                       **  Column #CI indicates the # of indexes
                                           satisfying  Q for each option

OUTRANKING MATRIX                      **  An Outranking relation * is the
       TYP  TYP  TYP                       one that satisfies both concordance
 TYP   -    -    -                         and discordance requirements.
 TYP   *    -    *                     **  An  -  indicates that there is
 TYP   *    -    -                         no outranking relations.



HIT ANY KEY TO CONTINUE

STEP 4 : INDIVIDUAL EVALUATION OF ALTERNATIVES
Method used : ELECTRE
```

Figure 41. User 3 / Concordance, Discordance, Outranking Matrix



```
ALT. CARDINAL RANKINGS    ORDINAL  RANKING       GROUP RESULTS

    USER1 USER2 USER3      USER1 USER2 USER3            R1 R2     R3     R4
Weig.:3.00  3.00  4.00
TYP    1.01  1.01  1.35       2     2     2         TYP   6  1.13  1.12  3
TYP    1.06  1.06  1.41       1     1     1         TYP   3  1.17  1.16  6
TYP    1.01  1.01  1.34       3     3     3         TYP   9  1.12  1.11  0





R1 : SUM OF RANKS                         R3 : MULTIPLICATIVE RANKING
R2 : ADDITIVE RANKING                     R4 : SUM OF OUTRANKING RELATIONS

HIT ANY KEY TO CONTINUE

 STEP 5 : COMPUTATION OF GROUP DECISION
 All the solutions have computed with AHP
```

Figure 42. Group Solution of the Problem
(Solved with Direct Mode)



```
ALT. INDIVIDUAL RANKINGS  ORDINAL  RANKING       GROUP RESULTS

    USER1 USER2 USER3        USE   USE   USE             R4    R1

TYP   0     0     0          3     3     3       TYP   0     9
TYP   2     2     2          1     1     1       TYP   6     3
TYP   1     1     1          2     2     2       TYP   3     6


R1 : SUM OF RANKS                     R3 : MULTIPLICATIVE RANKING
R2 : ADDITIVE RANKING                 R4 : SUM OF OUTRANKING RELATIONS

HIT ANY KEY TO CONTINUE

 STEP 5 : COMPUTATION OF GROUP DECISION
 All the solutions have computed with ELECTRE
```

Figure 43. Group Solution of the Problem
(Solved with Electre Mode)

LIST OF REFERENCES

1. Bui, X.T. and M. Jarke, "A Decision Support System for Cooperative Multiple Criteria Group Decision Making," Proceedings of the 6th International Conference on Information Systems, Tucson, Arizona, 101-113, 1984.

2. Bui, X.T. and M. Jarke, "A Datalogical Model for Multiple Criteria Decision Making," working paper, Naval Postgraduate School, Monterey, California, 1985.

3. Bui, X.T. and M. Jarke, "Communications Requirements for Group Decision Support Systems," Proceedings of the 19th Hawaii International Conference on System Sciences, Honolulu, Hawaii, January, 1986, Journal of MIS, Spring 1986.

4. Bernard, D., "Management Issues in Cooperative Computing," Computing Surveys, 11, 1, 3-17, 1979.

5. Deutsch, M. and R.H. Krauss, "Studies of Interpersonal Bargaining," Journal of Conflict Resolution, 52-76, 1962.

6. Walton, R., Interpersonal Peacemaking: Confrontations and Third Party Consultation, Reading, Mass., Addison Wesley, 1969.

7. Krauss, R.M. and M. Deutsch, "Communication in Inter. personal Bargaining," Journal of Personality and Social Psychology, 9., 15-20, 1966.

8. Eiseman, J., "A Third Party Consultation Model for Resolving Recurring Conflicts Collaboratively," Journal of Applied Behavioral Science, 303-314, 1977.

9. Kolb D.A., I.M. Rubin and J. McIntyre, Organizational Psychology, 4th edition, New Jersey, Prentice Hall, 1984.

10. Davis, R. and R.G. Smith, "Negotiation as a Metaphor for Distributed Problem Solving," Artificial Intelligence, 20,63-109, 1983.

11. Sprague, R. and E. Carlson, Building Effective Decision Support Systems, Englewood Cliffs, Prentice Hall, 1982.

12. Saaty, T. The Analytic Hierarchy Process : Planning, Priority, Allocation, New York, Mac-Graw Hill. 25,26,27,36, 1980.

13. Roy, B. and P. Bertier , "La methode ELECTRE II, une application au media-planning," in OR 72 M. Ross, (ed), (Dublin 1972), Amsterdam, North-Holland,291-302, 1983

14. Pasquier, J., T. Bui, M. Vieli and L. Wuillemin , "Choix d'un projet d'investissement a Bulle pour l'entreprise DSA-SFSA," Working Paper 79, University of Fribourg, Fribourg, 1979.

15. Heidel, K.J. and L. Duckstein, "Extension of ELECTRE Technique to Group Decision Making: An application to Fuel Emergency Control," working paper, TIMS/ORSA Joint National Meeting, Chicago, April 1983.

16. Crama. Y. and P. Hansen. "An Introduction to the ELECTRE Research Program," in Essays and Surveys on Multiple Criteria Decision Making Beckmann and Krelle (Eds),, New York, Springer-Verlag, 1983.

17. Mintzberg, H., "Managerial Work Analysis from Observations," Management Science, 18, 2, 97-110, 1971.

18. Roy, B., "Classement et choix en presence de points devue multiples (la methode ELECTRE)," R.I.R.O., 2, 57-7,1968.

19. Bui, X.T., "NAI -- A Consensus Seeking Algorithm for Group Decision Support Systems," Proceedings of the 1985 IEEE International Conference on Systems, Man and Cybernetics, Tucson, Arizona, 1985

20. Borda, J.C., "Memoire sur les Elections au Scrutin," Histoire de l'Academie Royale de Science,Paris, 1871.

21. Pasquier et al., "Analyse multicritere de fusion d'entreprise" in E. Borsberg (ed), Strategies et diversification d'entreprise, Lausanne, 1981.

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